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13. ABSTRACT

This report includes abstracts and bibliographic lists on major contractual subjects that were completed in July, 1972. The major topics are: laser technology, effects of strong explosions, geosciences, and particle beams. A section on material science has been included as the optional fifth topic, as well as a section on items of miscellaneous interest.

To avoid duplication in reporting, only laser entries concerning high-power effects have been included, since all current laser material will appear routinely in the quarterly bibliographies.

An index identifying source abbreviations and an author index to the abstracts are appended.

Details of illustrations in this document may be better studied on microfiche

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informatics inc
Systems and Services Company
6000 Executive Boulevard
Rockville, Maryland 20852
(301) 770-3000 Telex: 89-521

INTRODUCTION

This report includes abstracts and bibliographic lists on major contractual subjects that were completed in July, 1972. The major topics are: laser technology, effects of strong explosions, geosciences, and particle beams. A section on material science has been included as the optional fifth topic, as well as a section on items of miscellaneous interest.

To avoid duplication in reporting, only laser entries concerning high-power effects have been included, since all current laser material will appear routinely in the quarterly bibliographies.

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TABLE OF CONTENTS

1. Laser Technology

A. Abstracts

Goncharov, V. K., A. N. Loparev, and L. Ya. Min'ko. Self-igniting pulsed optical discharge in an erosive laser plasma. ZhETF, v. 62, no. 6, 1972, 2111-2114.

A variant on the optical plasmatron is described in which a self-igniting optical discharge is obtained from irradiation of a target surface. The technique was to defocus the incident beam such that the focal point was several millimeters above the target surface; vapor products from the surface, traveling at about 100 m/sec, would ignite on reaching the focal point and provide a "hanging" optical discharge for the remainder of the laser pulse. The experiment cited used an Nd glass laser at 1.5 μs pulsewidth and generating relatively low surface intensities on the order of $10^6 w/cm^2$. Various metals and dielectrics were tested as target materials, including ebonite, textolite, brass and a type POS-40 alloy. Depending on the material, a stable discharge was achieved in a 10 - 20 mm range above the target surface; spectral studies show discharge temperatures $\simeq 22,000^{\circ}K$. Streak photos of the discharge development are given; Fig. 1 shows one form of the discharge.

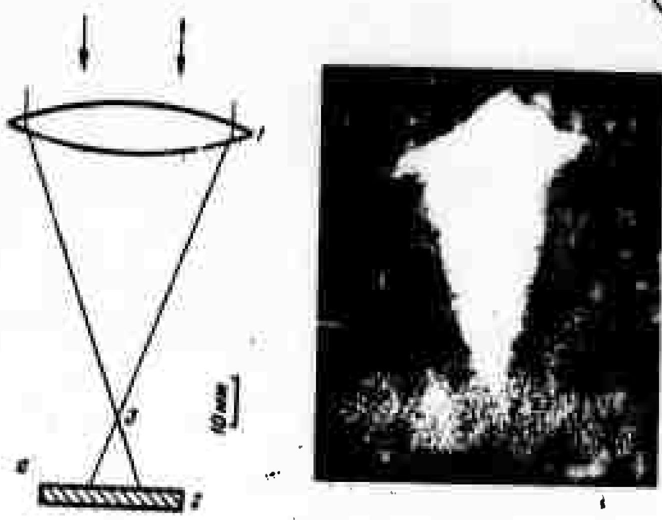

Fig. 1. "Hanging"
optical discharge.

The authors suggest adapting the effect to a c-w discharge, using a CO_2 laser for excitation. The effect is claimed as the first of its kind obtained at atmospheric pressure.

Fanchenko, S. D., and G. V. Sholin. Possible mechanisms of turbulent heating of a plasma by ultrashort laser pulses. DAN SSSR, v. 204, no. 5, 1972, 1090-1093.

The authors consider the initial ionization phenomena arising from interaction of a picosecond laser pulse with a very dense plasma. A feature of this case is that the optical field strength E is comparable to intra-atomic field E_a; this results in an ionization time τ_{ion} on the order of or less than electron-atom on electron-ion collision time, and possibly less than the laser wave period. The model used assumes a picosecond pulse with optical

frequency Ω falling on a condensed neutral target. During the first portion of the optical wave rise time, light penetrates the target virtually without ionization taking place; as the optical field approaches its peak of E, ionization begins but with an electron plasma frequency $\omega_{p\ell}$ still below Ω. As $E \rightarrow E_a$ the affected electrons proceed from bounded to unbounded motions in a time interval $\approx 10^{-16}$ sec. The authors then treat the two general intervals of collisionless plasma heating which ensue, namely when $\omega_{p\ell} < \Omega$ and $\omega_{p\ell} > \Omega$. Ionization parameters are obtained taking into account the magnetic piston effect exerted by the optical field when $\omega_{p\ell}$ overtakes Ω. Results show that at this point a beam of electrons forms in the focal region which may attain directional energies of 10^4 ev. Calculations based on a typical set of plasma parameters show that this current may exist for up to 10^{-12} sec. and reach densities above 10^{12} a/cm^2. It is emphasized that these deductions apply only to the initial one or two periods of laser pulse oscillation, applied to a neutral medium. Analogous effects from shock-wave and electron beam heating of a plasma are also noted.

Laboratory of laser beam mechanics. Nauka i zhizn', no. 2, 1972, 54-56.

Tests on mechanical effects of laser beams on optically transparent polymers are discussed. The destruction of plexiglass when exposed to a laser beam is explained by the presence of structural inhomogeneities. This was proven by experiments using a measured quantity of fine dust particles added to a polymer test specimen. After laser exposure, the maximum number of

damage centers was found to correlate with the number of injected microadmixtures. The polymer destruction process takes place in three stages: 1) generation of opaque centers; 2) heating and decomposition of material in the center region, and 3) destruction of the material surrounding the center. The cause of the thermal centers in polymers exposed to laser beams is not known, but it is assumed that thermal stress produces cracks in polymers, which strongly absorb radiation energy. Three photographs are given illustrating the destruction of a clear plastic by laser beam.

<u>Laboratory of polymer mechanics</u>. Nauka i zhizn', no. 2, 1972, 53-54.

Fig. 1. Microstructure of plexiglass. Distinct boundaries divide the substance into separate aggregates of a size on the order of a micron.

Findings of investigations of the relationship between the strength and structural properties of polymers are briefly reviewed. Laser beam radiation caused destruction of polymers, usually along the boundaries of structural formations. The structural bond of a plexiglass was about 10 times weaker than

the molecular strength; accordingly, destruction was noted along the bonds well before molecular destruction. Molecular destruction can be caused by both heat and light. The wavelength of laser radiation is such that at low intensities unstressed polymer molecules do not absorb the waves; but internal destruction does take place and cracks are observed. The aggregate structure of the substance plays an important role; e.g. the less the aggregate size, the greater the amount of cracks in polymers. The investigations show that organic glass and other amorphous polymers contain hyper-molecular structures. Figure 1 shows the microstructure of a plexiglass.

Geguzin, Ya. Ye., A. K. Yemets, and Yu. I. Boyko. Lowered optical strength of transparent solids with macroscopic defects. FTT, no. 5, 1972, 1565-1566.

An experiment is briefly described which attempted to correlate the degree of porosity in glass with its optical strength σ in laser applications. The case considered assumes that the characteristic linear dimension of the pore is greater than laser wavelength λ; in such cases for glass or ionic crystals, as much as 70% of light incident on thepore may be reflected, resulting in interference with the transmitted beam and generation of thermal damage centers. Tests to show this effect were done with a silicate glass containing a dispersed powder, sintered to form a porous medium with pore size $\approx$ 5 microns and a mean pore spacing of 30 microns.

The porous glass was exposed to a He - Ne laser beam at 1.06 μ and a 50 msec pulse width, together with a non-porous glass. Results show that for the latter, σ was 6×10^{14} erg/cm$^2 \cdot$ sec, dropping to 2.5×10^{14} erg/cm$^2 \cdot$ sec for the porous specimen. The relation of the pore structure to color centers is noted as having a definitive effect on the optical strength characteristics. In another step of the test the porous medium was modelled on a larger scale by using spherical quartz glass beads, suspended in a medium with a higher refractive index than the beads. No other data are given for this portion; however, Fig. 1 shows the medium, and an interference pattern obtained also at $\lambda = 0.63\mu$. The results with the

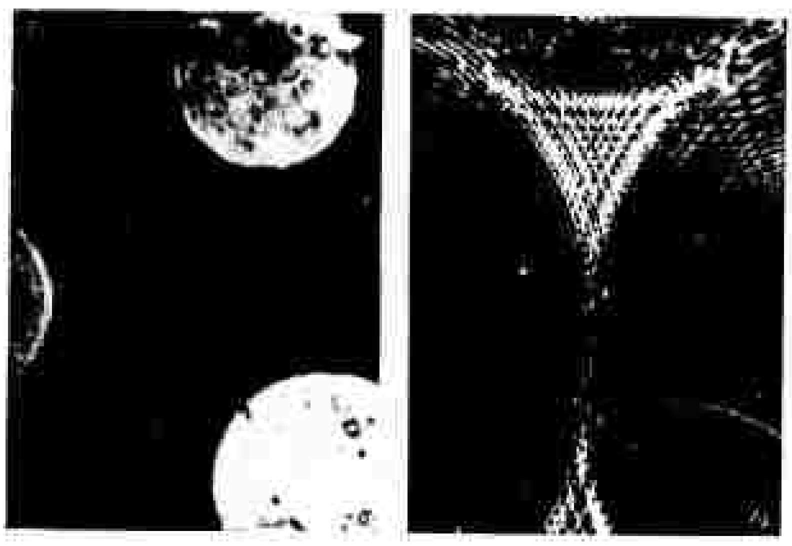

Fig. 1. "Pore" model, and interference pattern parallel to equatorial plane. X240.

model were effectively identical to those with the original sintered glass.

Buechl, K., K. Eidmann, H. Salzmann, and R. Sigel. Evidence of nonthermonuclear neutron production in a laser-generated deuterium plasma. IPP-Berichte, v. 28, no. 4, 1971, 9 p. (RZhF, 5/72, no. 5G307) (Translation)

Several diagnostic methods were used to study characteristics of nuclear reaction synthesis, as observed in a deuterium plasma generated by laser-target action. When the target was exposed in a chamber filled with low-pressure gas, the neutron yield dropped to zero. It is concluded that the observed reaction syntheses were of a nonthermonuclear type.

Kaliski, S. Generalized equations for laser heating of a dual-temperature plasma with allowance for heat of thermonuclear synthesis. Biul. WAT J. Dabrowskiego, v. 20, no. 12, 1971, 25-30 (RZhF, 5/72, no. 5G299) (Translation)

Generalized equations are derived for laser heating of a plasma to obtain fusion, for the case of different ion (T_i) and electron (T_e) temperatures. The equations are based on the following simplifying assumptions: bremsstrahlung depends only on T_e, heat yield only on T_i; radiation losses are negligible; thermal conductivity of ions is small relative to that of electrons; electron and ion densities are roughly equal; and the mechanical parameters of the system are not distinguishable by ion and electron component. Equations for laser heating of of the plasma are obtained for $T_i=T_e$.

Batanov, V. A., V. K. Goncharov, and L. Ya. Min'ko. Powerful optical erosion plasmatron. ZhPS, v. 16, no. 5, 1972, 931-934.

A versatile laser-driven plasmatron is described which may be compared to the one described previously by Goncharov et al in this report. In the present design the simple chamber shown in Fig. 1 was used to

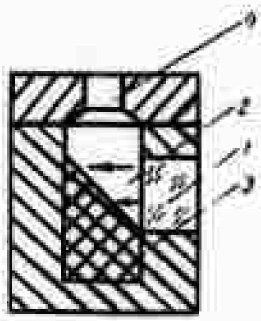

Fig. 1. Laser plasmatron
1- quartz window; 2- chamber;
3- target material; 4- exit nozzle

generate a plasma jet from any given target material, with the plasma driven out through the nozzle by generated pressure. By varying pulse parameters, chamber dimensions, fill gas, etc., a wide range of plasma jet characteristics can be obtained, ranging from subsonic to supersonic. The authors used an Nd glass laser at 0.8 millisecond pulses of 5 kj peak energy, in a quasi-cw regime, to develop target surface densities on the order of 10^6 w/cm^2. Glass textolite was used as target material, and helium at pressures from 5 x 10^{-2} torr to several atmospheres served as the fill gas. The many possible variations in jet parameters are discussed and both high-speed and streak photos are given of jet propagation. Table I compares results of two modes. The results generally show the versatility of this type of low temperature plasmatron.

Jet type	E, joules	Nozzle dia., cm	Chamber pressure, atm	Exit velocity km/sec	Adiab. index, γ	Mach no.
With shock wave	3.0	0.9	11	3.1	1.67	—
With periodic structure	2.2	0.9	8	2.6	1.67	1.9

Table I. Comparative data on supersonic nondivergent plasma jets

Aseyev, G. I., and M. L. Kats. Destruction mechanisms of alkali halide crystals and multi-photon ionization of impurity centers. FTT, no. 5, 1972, 1303-1307.

The destruction of a series of natural and impure alkali halide crystals (NaCl, KCl, KBr, NaBr, KCl-Eu, KCl-Ag, KCl-Tl, and KCl-In) under the effect of ruby and neodymium lasers was investigated in a free-running regime (energy ~ 1.5 joule, duration ≈ 500 μsec). Beam focusing on the specimens was done by f = 50 and 150 mm lenses. The destruction mechanism in crystals is explained in terms of Brillouin forced dispersion and local heating. The temperature at the damage site was approximately 5000°C at a near critical power density. Forced dispersion components were not observed. Results show little likelihood of destruction due to hypersonic phonons and high-frequency breakdown; the primary destruction mechanism is rather the local heating associated with absorption of a portion of the laser energy by crystal structure defects. The dynamics of the destruction process and causes of optical fatigue in alkali halide crys-

tals are outlined. It is shown that a decrease of at least one unit of the suggested photon level of the multi-quantum excitation process in photoconductivity of activated alkali halide crystals is associated with the thermal ionization of excited states of impurity centers. Graphical and photographic data of experimental results are included.

Bedilov, M. R., K. Khaydarov, and Kh. Babadzhanova. Nature of radiation defects formed on the surfaces of solids by ruby laser radiation. IAN UzbSSR, Ser. fiz-mat. nauk, no. 2, 1972, 66-68.

Results are described of an experimental investigation of damage processes on the surface of solids from ruby laser radiation in a free-running regime. Radiation energy was 1-3 joules and maximum power density was $\sim 10^7$ watt/cm^2; the beam was focused using a f = 50 mm lens. Targets were W, Mo, Ni, Zn, and Si, purified by laser radiation and placed in a 10^{-6} torr vacuum. Radiation processes were studied using microscopic and oscillographic methods, which provided data on integral and time characteristics of target surface defects during the laser pulse period. Integral defects formed by 800 μsec exposure were studied by microscope. In the 0.6-2 joules energy range, growth of surface radiation defects was strongly dependent on the nature of target and laser energy. At 0.6-1.0 joules, the target structure was predominantly band-like; but melting zones and craters did not appear. Individual 150-200 μ microcraters were formed however on the surface due to the intensive laser pulse peaks. With an increase of energy to 2 joules, the band structure disappeared and macrocrater and melting zones were observed on the target. The macrocraters were almost identical, nearly circular and their size was a function of target type, varying between 800 and 1050 μ. For W, Mo, Ni, and Zn targets, macrocraters attained 800, 1050, 950, and 1200μ respectively, at a laser energy of 2 joules. Ion current variations were recorded by an

oscillograph in synchronism with the laser pulse to determine the defect formation rate, energy absorption and changes in crater structure with time. Typical oscillograms of ruby laser pulsed radiation at 0.6 and 2 joules and simultaneously obtained pulsed ion current with a tungsten target are shown in Fig. 1.

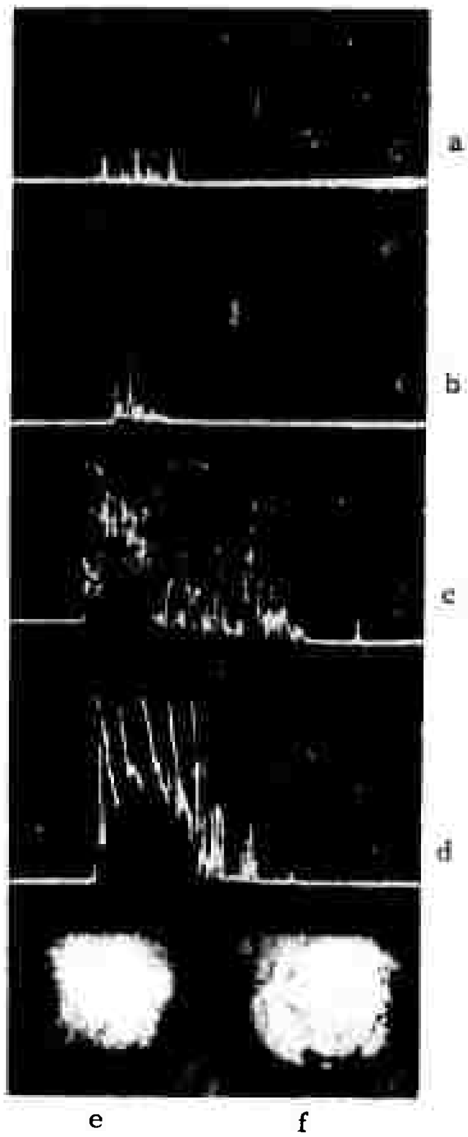

Fig. 1. Oscillograms of laser radiation at 0.6 joule (a), and 2 joules (c); ion currents of W target at 0.6 joule (b) and 2 joules (d); and defects formed on the surface of W target at 0.6 joule (e) and at 2 joules (f).

From the oscillographic results, the authors conclude that at low laser energies, ion currents assume a peaking character, are short in duration, occur after the start of the laser pulse, and are possibly connected with the formation of band structures and microcraters; at higher

energies, ion currents have a quasi-continuous character, and increase in duration and amplitude, which is related to formation of craters and melting zones.

Khazov, L. D. Effect of a powerful optical field on transparent dielectrics. IN: Trudy Gosudarstvennogo opticheskogo instituta, v. 41, no. 172, 1971, 22-29. (RZhF, 6/72, no. 6D1230)

A review is given of basic experimental results and qualitative concepts on the interaction of powerful single-pulsed optical radiation with transparent dielectrics. Particular emphasis is given to surface destruction. The experimental results are explained on the basis of an intense internal photoeffect, generated at the dielectric surface by the high density of local surface electron states. It is proposed that the surface strength of transparent dielectrics could be increased by reducing the density of surface defects.

B. <u>Recent Selections</u>

i. <u>Beam-Target Effects</u>

Adam, A., D. Horvath, P. Hrasko, Zs. Kajcsos, and M. Labadi. <u>Positron annihilation in a laser radiation field.</u> Kozp. fiz. kut. intez. no. 72, 1971. (RZhF, 5/72, #50196)

Arkhipov, Yu. V., N. V. Morachevskiy, V. V. Morozov, and F. S. Fayzullov. <u>Energy balance and destruction dynamics of transparent dielectrics under laser irradiation.</u> FTT, no. 6, 1972, 1756-1760.

Drozdov, S. A., and V. F. Salokhin. <u>Pulse heating of a finite-width plate at the interface between two media.</u> I-FZh, v. 22, no. 6, 1972, 1118-1119.

Kapel'yan, S. N., and Z. M. Yudovin. <u>Temperature field in metals following the action of pulsed thermal flux.</u> I-FZh, v. 22, no. 6, 1972, 1100-1104.

Korotin, A. V., and L. P. Semenov. <u>Vaporization of crystals from the action of external excitation.</u> IN: Institut eksperimental'noy meteorologii. Trudy, no. 30, 1972, 65-71.

Kuznetsov, A. Ya., I. S. Varnasheva, A. A. Poplavskiy, and G. P. Tikhomirov. <u>Destruction of reflective dielectric coatings by laser radiation.</u> OMP, no. 3, 1972, 39-42.

Lokhov, Yu. N., G. V. Rozhnov, and I. I. Shvyrkova. <u>Kinetics of forming a liquid phase from the action of a point heat source, taking heat of phase transition into account.</u> FiKhOM, no. 3, 1972, 9-17.

Nikiforov, Yu. N., V. A. Yanushkevich, and A. V. Sandulova. Change in electric properties of p-Si crystal whiskers from the action of giant laser pulses. FiKhOM, no. 3, 1972, 132-134.

Sultanov, M. A. Razrusheniye nekotorykh prozrachnykh dielektrikov pod deystviyem neodimovogo i rubinovogo lazerov v rezhime svobodnoy generatsii. (Damage in various transparent dielectrics from free-running ruby and neodymium lasers). Fiz-tekhn. institut AN TadzhSSR. Dushanbe, 1970, 19 p.

ii. Beam-Plasma Interaction

Bonch-Bruyevich, A. M., Ye. N. Kalitenevskaya, and T. R. Razumova. Effect of single-pulse ruby laser radiation on a mercury lamp plasma. OiS, v. 32, no. 6, 1972, 1171-1175.

Emrich, R., and R. I. Soloukhin. Resonant absorption of laser radiation by methane behind a shock wavefront. FGiV, no. 1, 1972, 92-98.

Fanchenko, S. D., and G. V. Sholin. Possible mechanisms of turbulent heating of a plasma by ultrashort laser pulses. DAN SSSR, v. 204, no. 5, 1972, 1090-1093.

Goncharov, V. K., A. N. Loparev, and L. Ya. Min'ko. Self-igniting pulsed optical discharge in an erosive laser plasma. ZhETF, v. 62, no. 6, 1972, 2111-2114.

Kaliski, S. Averaged Equations of the Combined Process of Hydrodynamic Expansion and Conduction Heating of Plasma, the Recovered Energy of Nuclear Fusion Being Taken into Consideration. I. The Plane Problem. Bull. Acad. Pol. Sci. Series des sciences techniques, v. 20, no. 4, 1972, 57-64.

Kaliski, S. Alternative Description of the Conduction-type Laser Heating Process of Two-temperature Plasma in the Spherically Symmetric Case, the Nuclear Fusion Energy Bring Taken into Consideration. (ibid), 65-72.

Pyatnitskiy, L. N., G. P. Khaustovich, and V. V. Korobkin. Device for plasma diagnostics by an optical scattering method. Author's Certificate USSR, no. 279812, published 9/15/71 (RZh Elektr, 5/72, #5A202P)

Rezvov, A. V. Effective boundary conditions in the theory of e-m wave penetration into plasma. ZhTF, no. 6, 1972, 1120-1129.

2. Effects of Strong Explosions

A. Abstracts

Saltanov, G. A., and L. I. Seleznev.
Variations of flow parameters and flow structure of moist vapor, for the case of interphase heat and mass exchange in the relaxation zone behind a shock wavefront. TVT, no. 6, 1971, 1200-1206.

Relaxation phenomena behind a stationary shock wavefront in moist vapor are analyzed, with allowance for relatively low concentrations of spontaneously condensed fine drops and in the absence of gliding phase motion. The numerical solution of a set of equations of motion determined the flow parameters (p, T, c), flow structure (particle-size distribution), and shock wave width for the thermodynamic equilibrium of a two-phase medium ahead of the shock wave. Theoretical data were found to be in good qualitative agreement with the experiment, e.g. using a Laval nozzle.

Kuz'menko, N. Ye., Yu. Ya. Kuzyakov, L. A. Kuznetsova, I. N. Kurdyumova, and B. N. Chuyev.
Experimental determination of the oscillator strength of the $A^2\Delta - X^2\Pi$ electron transition in a carbon monohydride molecule, TVT, no. 5, 1971, 905-910.

The electron absorption spectrum of a CH molecule behind a reflected shock wave front was measured in an acetylene-argon mixture to determine the absolute oscillator strength f_e of the

$A^2\Delta - X^2\Pi$ electron transition. The determination of f_e is essential because the CH molecule is one of the main components of the high-temperature plasma formed by hydrocarbons. The optical absorption of gas was used as a method of f_e determination to independently verify f_e values obtained earlier by several authors from CH molecule life-time data in $A^2\Delta$ excited state. Preliminary calculations of the temperature and gas composition behind the front of an incident shock wave propagating at ~ 3 km/sec led to the selection of the 1:4 C_2H_2 - Ar mixture used in the shock-tube experiments. A 15 torr pressure was maintained in the low-pressure chamber to obtain the optimum spectral intensity. The $\Delta\nu = 19.5\ cm^{-1}$ region of the absorption spectrum, which included (0, 0) and (1, 1) rotational bands, was selected for measurement of f_e of the $A^2\Delta - X^2\Pi$ transition. The integral absorption coefficient $\int K_\nu\, d\nu$ within the selected spectral region was estimated to be equal numerically to the area of the absorption band on the microspectrogram because the (0, 0) and (1, 1) bands must totally overlap. The $\int K_\nu\, d\nu$ values photometrically determined from four selected spectrograms were used to calculate the square matrix element $\left| R_e^{nm} \right|^2$ of the electric dipole moment of the $A^2\Delta - X^2\Pi$ transition, and hence the f_e value. The experimental gas parameters, shock wave velocities, $\int K_\nu\, d\nu$ data and the calculated $\left| R_e^{nm} \right|^2$ and f_e data are tabulated for four spectrograms. The mean $f_e = (1.9 \pm 0.3) \times 10^{-3}$. The arithmetic mean of the three f_e values found earlier from the lifetimes of the $A^2\Delta$ state and recomputed with allowance for the (1, 1) band was 2.7×10^{-3}. The recommended f_e ($A^2\Delta - X^2\Pi$)CH value is $(2.3 \pm 0.4) \times 10^3$.

Pavlov, A. I. The prevention of failure and impermissible deformations during high-speed impact action. IN: Teoriya i praktika vysokoskorostnoy deformatsii metallicheskikh materialov. Moscow, 1971, 1-2 (RZhMekh, 5/72, #5V975)

Problems are discussed of the prevention of failure and impermissible deformations during high-speed impact action upon spherical, cylindrical, and flat surfaces. A possible mechanism of the deformation processes is analyzed, and means of governing these processes are determined; particular consideration is given to the role of a thin layer of a material of low acoustic density between the element surface and its base.

Lobanov, V. F. and Yu. I. Fadeyenko. Calculation of the stresses in an elastic sphere situated in a hypersonic stream. IN: Dinamika sploshnoy sredy, Novosibirsk, no. 7, 1971, 226-232 (RZhMekh, 5/72, #5V285)

An axisymmetric problem is considered, dealing with determination of the stress field originating in a hollow elastic sphere during its presence in a hypersonic stream. The aerodynamic pressure acting upon the sphere is considered to be known and is given in the form of a function that depends upon the angular coordinate in accordance with Newton's law. The inner surface of the sphere is stress-free. The solution is represented in series form using Legendre polynomials. Numerical calculations were conducted on a digital computer for a solid sphere and for a hollow sphere with a Poisson coefficient $m = 2$.

Yermak, Yu. N. and V. Ya. Neyland. The effect of viscosity upon shock wave detachment during flow around a cylinder by a hypersonic stream. Uchenyye zapiski Tsentral'nogo aero-gidrodinamicheskogo institute, v. 2, no. 6, 1971, 41-47. (RZhMekh, 5/72, #5B315)

An investigation is made of the effect of viscosity and thermal conductivity upon detachment of the shock wave from the surface of a circular cylinder in a hypersonic stream of viscous gas, with vertical interaction of the boundary layer with the nonviscous shock layer. It is shown that in distinction from the case of vortical interaction on a sphere, viscosity and thermal conductivity exert a strong influence in this case upon detachment of the shock wave, since the greatest part of the shock-layer thickness consists of a region of slow viscous flow, lying near the surface of the body.

Borovoy, V. Ya., Kharchenko, V. I. Experimental investigation of flow and heat exchange in the separation zone on an axisymmetric body with a conic shield. MZhiG, no. 3, 1972, 35-40.

The results are presented of an experimental investigation of the distribution of pressure and heat exchange on the surface of a conic shield mounted on a cylinder with a conic nose. The shield inclination angle was varied from 10 to 60°, the ratio of the cylinder length to the shield base diameter was $l/D = 0.5$--2. The experiments were conducted at Mach number $M_{\infty} = 5$, pressure $p_{o} = 8$ bar, stagnation

temperature T_o = 400--773^o K, and a Reynolds number, calculated on the basis of the total length model, Re = 0.6×10^6.

Shadow photographs show that on a model with an angle of shield inclination φ = 30^o and an angle of attack α = 0, a separation zone develops, with shock wave formation at points of separation and attachment. At values of $\varphi \geq 30^o$, the laminar mixing layer in the stall zone becomes turbulent, and separation lines are clearly detected on the basis of points applied by washable paint. On a model with φ = 30 at α = 10^o, points applied in the separation zone were practically not washed out at all.

Measurement of change of the angle of inclination of the stall zone to the cylinder generatrix, Θ, in relation to the cylinder length at α = 0 (φ = 10, 20, 30^o), revealed that with sufficient cylinder length, equal values of angle Θ (4--4.5^o) were yielded for all shields; this corresponds to a separation point along the cylinder beyond the inflection point, i.e., to free interaction. As the angle of attack is increased, the length of the stall zone on the windward side decreases sharply, and increases on the lee side. After the separation point moves along the windward side beyond the inflection point, the separation angle Θ does not change with further increases of the angle of attack and comprises 3.5^o, i.e., differs little from the separation angle during free interaction at α = 0.

Pressure was measured on the shield only. The pressure distribution along the relative length of the shield generatrix at φ = 30^o was obtained for α = 0, 10, and 30^o. At α = 0, the pressure in the

separation zone is almost constant. Calculated values of the pressure coefficient C_p for the "fluid cone" formed by the stall zone agree with the measurement results. In the region of boundary layer, the pressure increases, and toward the end of the shield becomes constant. Analogous data were also obtained for tests of shields with other values of φ . The pressure on the windward generatrix increases when the angle of attack is increased and decreases on the lee generatrix. Experimental data for the region of attached flow on the windward generatrix at $\alpha = 10^\circ$ also coincide with the calculated values. In tests on models with $\varphi = 20^\circ$ and 30° at $\alpha = 30^\circ$, a pressure peak appeared on the windward generatrix as a consequence of interaction of the forward shock and the shock starting at the point of transition from the cylinder to the shield. At smaller angles of attack the region of interaction was located behind the shield. For heat tests the $\sim$ 0.5 mm thick shields were made of stainless steel. The specific heat flux was calculated in terms of the Stanton number, St.

The heat flux distribution along the length of the shield for $\alpha = 0$ has a maximum when $\varphi < 60^\circ$. When $\varphi = 20$ and 30°, the heat-flux maximum is behind the point of attachment, and at $\varphi = 45^\circ$ the two points practically coincide. At $\varphi = 60^\circ$ attachment takes place at the rear edge of the shield, and the maximal heat flux could not be measured. The value of the maximum Stanton number St* rises sharply with an increase of φ , primarily due to a gas-density increase and an angle of incidence increase of the stall-zone flow line with the shield generatrix. On the basis of the maximal value of the Stanton number St_0*, computed on the basis of the flow parameters at

the outer boundary of the stall zone, it is shown that during turbulent flow in the stall zone at $\alpha = 0$, the value $St_o*/\sin(\varphi - \theta)$ changes relatively little in relation to φ. The values of St for various cylinder and nose-cone variants did not vary by more than 30%.

In a study of the influence of α on heat exchange, it was found that even at $\alpha = 1$--2°, the heat flux distribution on the shield is considerably deformed due to stall zone deformation: on the windward generatrix the maximum is shifted forward, and on the lee side it is shifted to the rear, with the value of the maximal heat flux undergoing virtually no change. As α is increased to values ranging up to 30°, the degree of nonuniformity of heat flux distribution along the length of the generatrix does not increase; in many cases it even decreases considerably. This is because the separation zone length on the windward surface decreases and practically the entire shield is situated in an attached flow as α is increased.

Savityuk, V. I., P. I. Plakhotnyy, and I. P. Sadovoy. Distribution of the stresses in an anisotropic massif at the time of the detonation of an explosive charge. Razrabotka rudnykh mestorozhdeniy. Respublikanskiy mezhvedomstvennyy nauchno-tekhnicheskiy sbornik, no. 13, 77-79 (RZhMekh, 5/72, #5V618)

Results are presented of theoretical research on the stress distribution in an anisotropic massif, with account taken of the orientation of the free surface and the core charges in relation to the planes of

relaxation created by the stratification of the material. Formulas are proposed for determining the stresses in an anisotropic massif, as well as for determining the zone of destruction from detonation of a single core charge.

Nematov, L. Propagation of one-dimensional spherical shock waves in soil (direct problem). IN: Voprosy vycheslitel'noy i prikadnoy matematiki, Tashkent, no. 7, 1971, 115-119 (RZhMekh, 5/72, #5V501)

The problem is considered of the propagation of a shock wave formed during the expansion of a sphere, in an unbounded space. At the initial moment of time, the spherical surface instantaneously acquires a finite velocity, which then changes in accordance with a given law. The solution is worked out on a computer by the method of characteristics. The obtained values of the velocity and deformation of particles in the shock wave are presented as functions of time and space coordinates.

Dolmatov, K. I. Current break during electric explosion of a wire, IAN Uzb SSR, Ser. fiz.-mat. nauk, no. 1, 1972, 97-98.

Characteristics of a current break were studied experimentally for discharge of two capacitors across a thin tungsten or molybdenum wire. Current intensity was determined by measuring voltage across a 0.0198 ohm resistance in the circuit. Duration τ of the current break was

measured as a function of discharge potential U, and wire length l, diameter d, mass m, and resistance R. The experimental plots show that τ rapidly decreases with an increase of U from 1 to 3 kv for 15 mm. tungsten wires of 0.129 - 0.200 mm. dia. and 40 mm. molybdenum wires of 0.10 - 0.80 mm. dia. In contrast, at a constant U = 2.5 or 3 kv, τ increases with increased l and attains a very high value with a sufficiently long wire. To assess the effects of increased m and R simultaneous with an increase in f, W and Mo wires of varying m and R = 2.8 and 0.449 ohm, respectively, were exploded. The experimental plots reveal that τ is directly proportional to m, i.e., τ = 750 m for W and 2,250 m for Mo. Wires of different R, but a constant m = 60.36×10^{-4} for W and 15.76×10^{-4}g for Mo, were also exploded (Fig. 1).

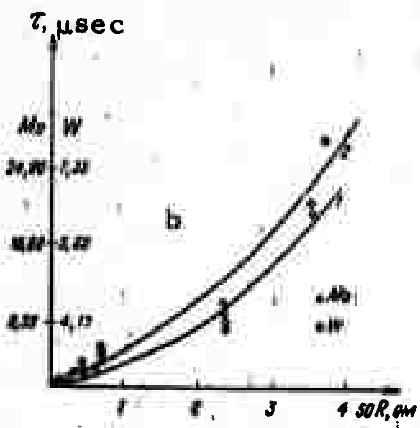

Fig. 1. Experimental τ (R) plots of W and Mo exploding wires

The experimental results were in agreement with the theory of current break by micro-disruptions in wire material.

Kaliski, S. Cumulation of plasma and magnetic field during explosion of a heavy conductive shell. Biul. WAT J. Dabrowskiego, v. 20, no. 11, 1971, 9-16 (RZhF, 4/72, #4G16).

The problem of combining plasma cumulation with that of the initial magnetic field during an explosion oriented toward the center of a system is treated by the method of averaging. A solution is presented to equations of plasma motion in a magnetic field and an equation of energy in plane and cylindrical systems. Using a general solution, separate boundary conditions are derived for cumulation of the magnetic field or the plasma. The description of the boundary condition of plasma cumulation alone by the method of averaging is considered meaningless, however, without allowance for additional sources (e.g. lasers, magnetic fields, and mechanical pressure) acting upon the plasma.

Kaliski, S. Cumulation of a plane electromagnetic field at relativistic initial velocities of a conductive shell. Biul. WAT J. Dabrowskiego, v. 20, no. 11, 1971, 17-23. (RZhF, 4/72, #4G7).

The problem of magnetic field cumulation during a field-oriented explosion of a heavy conductive shell is analyzed in an approximation of plane geometry. Quasi-relativistic velocities of the conductive shell were investigated (the terms of the $(v/c)^2$ order, where

v is the shell velocity, are disregarded). Using the method of characteristics, Maxwell equations are solved with a boundary condition formulated by a standard differential equation which describes motion of the shell. In the particular case of $v/c \leq 1$, field cumulation is described by a well-known solution for a quasi-static state.

Malyshev, V. V. Equation of state for uranium hexafluoride over a wide range of state parameters. Atomnaya energiya, v. 32, no. 4, 1972, 313.

Experimental data on saturated vapor pressure P_s, densities ρ_v and ρ_l of UF_6 vapor and liquid at equilibrium are approximated by the equations

$$\lg P_s\,(\text{бар}) = 10{,}5488 - 2344{,}4/T - 0{,}013624T + 1{,}0347 \cdot 10^{-5}T^2; \tag{1}$$

$$\rho_v\,(\text{г/см}^3) = 1{,}369 - 0{,}2820\Theta - 0{,}0211\Theta^2 + 0{,}00503\Theta^3; \tag{2}$$

$$\rho_l\,(\text{г/см}^3) = 1{,}369 + 0{,}0616\Theta + 0{,}2757\Theta^2 + 0{,}09975\Theta^3 + 0{,}01677\Theta^4 - 0{,}001028\Theta^5, \tag{3}$$

where

$$\Theta = (504{,}5 - T)^{1/3}. \tag{4}$$

Compressibility of UF_6 was determined using a constant volume piezometer. Pressure to 242 bar, densities to 3.417 g/cm^3 and temperature in the 364 - 592°K range were measured with respective errors less than 0.1 - 0.2%, in the 0.05 - 0.13% range and 0.07°K. Equations (1), (2), and (3) describe the experimental data with an error less than 0.3% in the 364.0 - 504.5°K range, equal to 0.5% in the 403.7 - 504.5°K range, and to 0.2% in the 372.6 - 504.5° K range,

respectively. The critical parameters of UF_6, namely ρ = 1.369 ± 0.005 g/cm^3, $T_c = 504.5 \pm 0.2^oK$, $P_c = 46.0 \pm 0.1$ bar, and $S_c = \rho_c T_c R \mu / P_c = 3.55 \pm 0.02$, were determined from Equations (1) - (3). Heats of vaporization were calculated from the Clausins - Clapeyron equation using Equations (1) and (3) and were expressed by an approximate formula with a 1.1% error.

The UF_6 equation of state is given in the form of an interpolation polynomial of the 5th degree,

$$\frac{\pi\varphi}{\tau} = 3{,}55\left[1 + \sum_{n}\sum_{m} b_{mk}/\tau^{k}\varphi^{m}\right], \tag{5}$$

in variables $\pi = P/P_c m$, $\tau = T/T_c$, and $\phi = \rho_c/\rho$. The b_{mk} values in (5) are tabulated for m = 1-5 and k = 0-4. Equation (5) describes the experimental data with a 0.2 - 0.3% error in the region of superheated vapor ($\rho \leq 1.4$g/cm^3) and with a 1% maximum error at $\rho \leq 2.8$g/cu. cm. Secondary virial coefficient B values are tabulated for the 463.3 - 592.2^oK range. The intermolecular parameters were calculated from the Lennard-Jones (12-6) potential function. This paper is an extension of an earlier report by Malyshev on the same subject (February Monthly Report, p. 70).

Kestenboym, Kh. S., F. D. Turetskaya, L. A. Chudov, and Yu. D. Shevelev. Euler and Lagrange methods for calculations of point explosions in a heterogeneous atmosphere. IN: Trudy Sektsii po chislennym metodam v gazovoy dinamiki 2-go Mezhdunarodnogo kollokviuma po gazodinamike vzryva i reagiroyushikh sistem, 1969, T. 3. Moscow, 1971, 85-100 (RZhMekh, 5/72, #5B238)

A study is made of a strong point explosion in a nonviscous thermally nonconductive gas. It is assumed that the density and pressure of the atmosphere are altitude-dependent according to an exponential law. Motion is considered in the half plane Π $(r \geq 0)$, bounded by the axis of symmetry. The equations of unstabilized motion are written out in terms of Euler and Lagrange coordinates. Region G_0, containing the point in which the explosion occurs, is isolated in half plane π. In solving the problem, the boundary Γ_0 (t) of the region is selected in such a manner that within the entire G_0 region, the pressure could be considered constant. The region of difference calculation, G_1, is bounded by the curve $\Gamma_0(t)$, the shock wave front Γ_1 (t), and two segments of the axis of symmetry. The solution of a number of unidimensional problems, including the problem of a point explosion in a homogeneous atmosphere with account taken of counter-pressure, was checked by an applicable method for its verification, good coincidence being obtained with results of the work by D. Ye. Okhotsimskiy, I. L. Kondrashev, Z. P. Vlasov, and R. K. Kazakov (Trudy Matematicheskogo instituta AN SSSR, 1957, 50, 66. RZhMekh, 3/58, #2659). Fairly good correspondence is shown in comparison of the results of calculation of the title problem in terms of Euler and Lagrange variables.

Gurevich, A. V. Isothermal ionization of the lower atmosphere by radio waves. GiA, no. 4, 1972, 631-640.

An extensive analysis is made of the conditions required for local r-f heating of the ionosphere. The study is limited to altitudes $z < 60$ km, where an isothermal heating model is assumed to be applicable. It is shown that in the 20 to 50 km range, an excitation temperature of only 0.2--0.3 ev can yield local electron densities of $10^{11}/cm^3$ in discharge regions with dimensions on the order of meters. Expressions for heat loss via molecular conduction, radiation, and wind convection are derived, leading to the necessary heat balance conditions for sustaining the plasma. The author notes that his development assumes a wind velocity of not over 1 m/sec, whereas velocities in this altitude range are typically an order of magnitude greater. It follows that to sustain a plasma at reasonable r-f power would require the beam to track the excited region at approximately wind velocity. Theoretical data are included which correlate the various ionospheric and r-f parameters necessary for the desired excitation state.

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4. Particle Beams

A. Abstracts

Bashkatov, A. V., V. S. Postnikov, F. N. Ryzhkov, and A. A. Uglov. Determination of thermal fields during welding by a swept electron beam. FiKhOM, no. 2, 1972, 23-29.

Thermal processes during welding by a swept electron beam are considered in terms of saw-tooth, rectangular, sinusoidal and circular deflection modes. Analytical methods are proposed for calculating temperature fields for the various sweep modes, both along and across the weld; calculation were done by computer. Welds were made on a 2 mm thick steel sheet using the cited deflection modes at sweep rates of 50 to 100 Hz. In all cases the measured temperatures were from 14 to 17% below calculated values. Fig. 1 compares temperature fields for four deflection modes; highest heating is with the rectangular sweep where maximum energy dissipation occurs at each end of the sweep pulse.

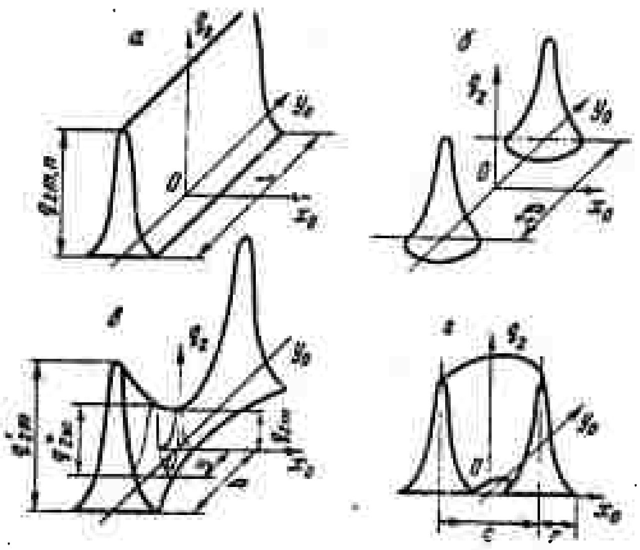

Fig. 1. Temperature field in steel welds a- saw tooth; b- rectangular; c- sinusoidal; d- circular beam sweep. 2D = total beam excursion

A comparison of temperatures calculated for three sweep modes is shown in Fig. 2.

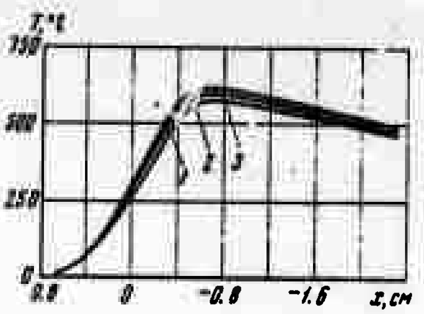

Fig. 2. Temperature gradients across weld 1- rectangular; 2- sinusoidal; 3- saw-tooth beam sweep. Beam excursion = 0.45 cm.

Bystrov, L. N., L. P. Zhukova, and Yu. M. Platov. Effect of electron irradiation on mechanical properties of Fe-Cr and Fe-Mo alloys. FiKhOM, no. 1, 1972, 19-22.

The effect of electron irradiation on the mechanical properties of Fe-Cr (15 and 20% Cr) and Fe-Mo (5% Mo) alloys was investigated. The alloys were smelted in vacuum from iron (purity 99.9%), chromium (99.8%), and molybdenum (98%). Flat specimens (0.5 x 3 x 20 mm) were annealed in vacuum (10^{-3} torr) and sealed quartz ampoules at 1000°C for 4 hrs. Specimen irradiation was by a linear electron accelerator with beam energy = 2.3 MeV, intensity - $10^{14}cm^{-2}sec^{-1}$. Irradiation temperature was kept constant by spraying specimens with a thermostatically controlled water jet (to 100°C) or by compressed air (200°C). Stress-strain curves were drawn by a tensile testing machine with automatic recording of tensile diagrams. Results of a study to find an optimum

irradiation temperature at which radiation effect is maximum are given in Table I. Specimen alloys Fe+20%Cr and Fe+15%Cr were irradiated

Irrad Temp. °C	$\Delta\sigma_{0.2}$, %		$\Delta\sigma_b$, %		$\Delta\delta$, %	
	Fe + 20% Cr	Fe + 15% Cr	Fe + 20% Cr	Fe + 15% Cr	Fe + 20% Cr	Fe + 15% Cr
20	+13	+ 9	−4	−1	− 7	− 7
100	+16	+ 9	−6	−3	−15	−10
200	+14	+10	−8	+1	−24	−11

Table I.

with a 1.3×10^{18}cm^{-2} dosage at 20, 100, and 200°C. The irradiation temperature did not significantly affect the yield point change ($\Delta\sigma_{0.2}$). The decrease of relative expansion up to destruction ($\Delta\delta$) with an increase of radiation temperature was more significant for the Fe+20%Cr alloys. Tensile strength also increased with a rise in temperature. The results of investigations on the per-dose relationship of radiation hardening of the Fe+20%Cr alloy at 100°C are shown in Fig. 1.

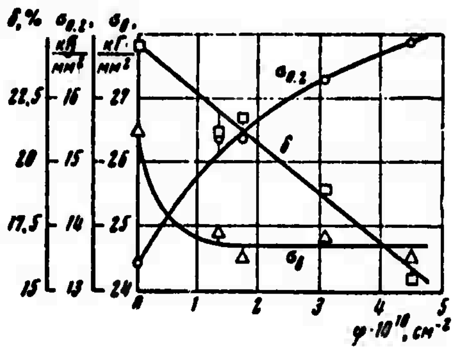

Fig. 1. Effect of electron radiation dose at 100°C on mechanical properties of Fe+20%Cr alloy.

The tensile strength σ_b at minimum radiation doses of (1-2) $\times 10^{18}$cm^{-2} was lowered by 7-8%, but thereafter, up to a dose of $4.5 \cdot 10^{18}$cm^{-2}, there was practically no change. The yield point $\sigma_{0.2}$ rose continuously; at the maximum dose, it reached a change of 25%. The relative expansion to destruction decreased continuously. The effects are connected with the precipitation of the σ phase in alloys due to radiation

accelerated diffusion.

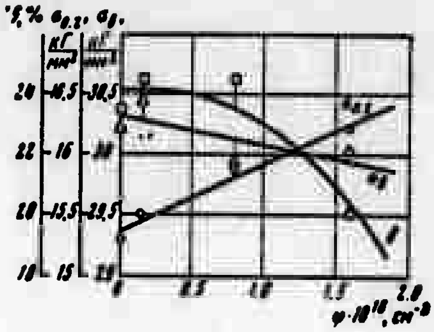

Fig. 2. Effect of electron radiation dosage at 20°C on mechanical properties of Fe+5%Mo alloy.

A similar effect is also noted for Fe-Mo, due to radiation initiation of ϵ-phase precipitation. In this case the change is comparatively smaller than in the Fe+20%Cr alloy.

Zhukov, M. F., A. S. An'shakov, G.-N. B. Dandaron, and M. I. Sazonov. Erosion of a tungsten cathode in nitrogen. Izvestiya SOAN SSSR, Seriya tekhnicheskikh nauk, v. 8, no. 2, 1971, 7-12.

The effectiveness was studied of nitrogen for preventing erosion of a thoriated tungsten cathode at high currents in a plasmatron, used for heating air, oxygen and other gases. The plasmatron in question has been described earlier by An'shakov, et al (Izv. SOAN SSSR. Ser. tekhn. nauk, v. 8, no. 2, 1970). The cathode is a tungsten rod, 10 mm long, soldered in a copper ring cooled by circulating water. Discharge of the nitrogen preventive gas was 3-4g/sec and that of the working gas was 30-70 g/sec. The effect of heat flow in the cathode is outlined and its relationship to current is plotted in Fig. 1. Results are discribed

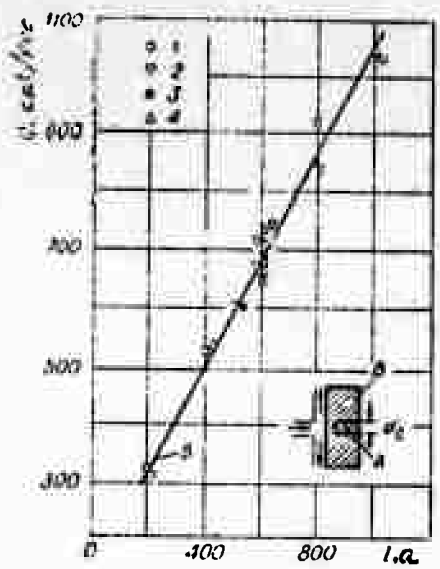

Fig. 1. Relationship of cathode heat flow versus current. 1- d_c=4 mm; 2- 5 mm; 3- 6.8 mm; 4- 9 mm; 5- per calculations. A- tungsten rod; B- copper rod.

of experimental determinations of current density in the cathode, assuming the arc spot diameter is equal to that of the eroding cathode surface, and the current density is constant. The shape of the cathode surface under the arc spot changed when the plasmatron was operated. At 600 a and a cathode diameter of d_c = 4 mm, there was no tungsten melting during the first 10 min. of plasmatron operation. In the next 10 min., the tungsten under the cathode spot proceeded to melt, and its surface after the arc was cut off was covered with protuberances. The was due to the inhomogeneity in current density and the variable rate of material ablation on different parts of the cathode surface. After about 20 min. of plasmatron operation, the diameter of the cathode spot, d_k, increased slightly.

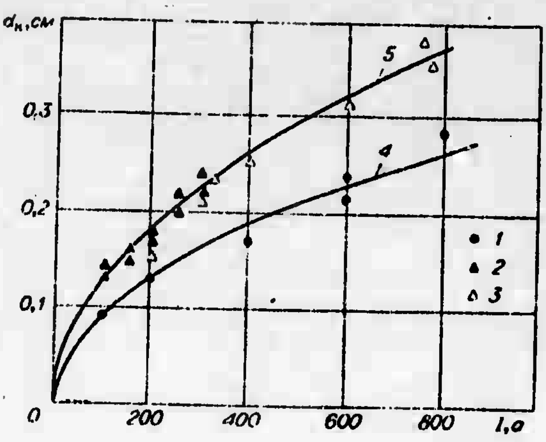

Fig. 2. Relationship of cathode spot diameter to arc current. 1- nitrogen; 2, 3- argon; 4, 5- per calculations.

Current densities, based on measurements of the eroding surface diameter of the tungsten cathode in nitrogen and argon, are virtually independent of the arc current and equal 1.5×10^4 for nitrogen and $7.5 \times 10^3 a \cdot cm^{-2}$ for argon in the 100-1000a range. Current densities of thermal emission form cathodes of pure tungsten or with admixtures of thorium oxide and barium aluminate, were calculated in relation to surface temperatures using the Richardson-Dushman formula. Comparison of calculated and experimental results on current density yields the following conclusions:

1. It is not possible to prevent the melting of pure tungsten in the medium considered.

2. A non-melting regime is possible in an argon arc when using thoriated tungsten. To establish a non-melting regime in a nitrogen medium, ways of decreasing current density must be found.

3. It is necessary to use activated tungsten with a work function below 2.5 ev to obtain a steady non-melting regime for a cathode working in nitrogen and other media.

Experiments were also conducted to find the specific erosion of a thoriated tungsten electrode in the nitrogen medium at 300-1000a. The tungsten rod had a diameter of d_c = 4 mm and was intensively cooled. The tungsten melted at the arc spot and material ablated in drops at one place. This was possibly due to a significant increase in current density and specific heat flow. A decrease in the cathode erosion rate is possible in nitrogen by optimizing the heat removal and maintaining the cathode surface temperature near 3600-3800°K. The minimum erosion corresponded to a specific value of cathode rod diameter near the cathode spot diameter. At I = 1000a, the minimum specific erosion was at a cathode diameter d_c = 4 4.5 mm. Results show that the tungsten rod diameter should be 10-30% larger than the cathode spot diameter. The relationship of a specific erosion of a tungsten cathode in nitrogen to current at a cathode diameter d_c = 4 mm, near to the optimum value, is given in Fig. 3 (point 1). Experiment duration was 0.5-2.5 hrs. The value of specific erosion lies between 3.10^{9} - 1.10^{-8}g/amp/sec. Calculations show that the rate of tungsten loss in nitrogen by equilibrium evaporation is about 1.5-8 times less than the experimental ablation rate of the cathode material. Evaporation is therefore considered to be one of the main causes of the loss of cathode material.

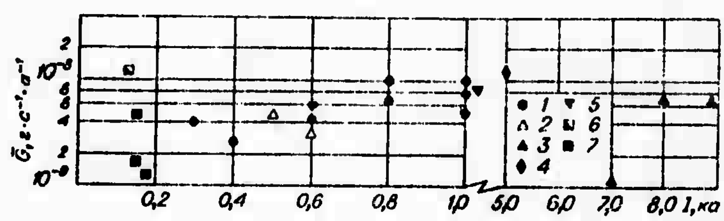

Fig. 3. Relationship of specific erosion of tungsten cathode to arc current. Nitrogen: 1- d_c=4mm. Argon: 2- d_c=4mm, l_c=14mm; 3- d_c=25.4mm, l_c=19mm; 4- d_c=12.7mm, l_c=12.7mm; 5- d_c= 8mm, l_c=20mm.

Goloborod'ko, V. T., and Yu. M. Kiselev. Using the Doppler effect to measure plasma velocity. TVT, no. 6, 1971, 1248-1252.

Two optical methods and systems using the Doppler effect are described, which are used to measure plasma velocity V from self-radiation in the optical range. The possibilities of measuring velocity of plasma components. magnitude and direction of particle motion, and a wide range (10^2 - 10^6 m/sec) of velocities are advantages of the methods. The Doppler shift of the wave length of a spectral line is given by

$$\delta\lambda_D = \lambda(V/c)(\cos\theta_1 - \cos\theta_2), \tag{1}$$

where c is the velocity of light and θ_1 and θ_2 are the angles of observation. A spectral system of $\delta\lambda_D$ measurement uses a high resolution dual-beam spectrometer developed by the authors (ZhPS, v. 10, no. 1, 1969, 13). The spectrometer simultaneously analyzes radiation from two directions. The optical arrangement includes a scanning Fabry-Perot interferometer. The 10^{-4} mμ wave length shift is measured by the shift of adjacent orders of interference. The second system of $\delta\lambda_D$ measurement is a Doppler tracking system in which a Fabry-Perot interferometer is used as a frequency detector, i.e., a narrow-band tunable filter with a harmonically modulated frequency (Fig. 1).

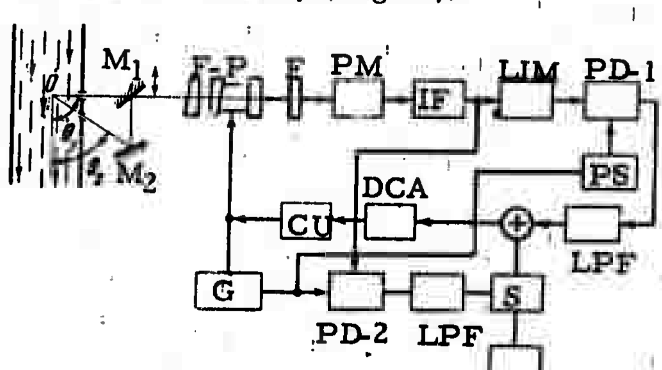

Fig. 1. Doppler tracking system.
IF- intermediate frequency amplifier; LIM- limiter; PD- phase detector; PS- phase shifter; LPF- low pass filter; DCA- dc amplifier; CU- control unit; S- switch; M- modulator.

The interferometer successively analyzes radiation from two directions (at θ_1 and θ_2 angles) using M_1 and M_2 mirrors. Tuning of the $(\lambda - \delta\lambda)$ wavelength is done by the tracking system and $\delta\lambda$ is measured by the variation in voltage across a piezoelectric ceramic sensor. It is shown that information about the average particle velocity and velocity distribution can be obtained from the recorded Doppler shift of spectral lines. The lower and upper limits of velocity measurement are determined by broadening of the spectral line profile and instrument sensitivity, respectively. The relative error of V measurement using the scanning Fabry-Perot interferometer is $\leq 3\%$. The use of the Doppler effect for V measurement is most advantageous for nonequilibrium plasmas.

Ul'yanov, K. N., and L. P. Menakhin. Current instability in gas at moderate pressures. ZhTF, no. 12, 1971, 2545-2551.

Experimental results for the discharge transitions from a homogeneous to an inhomogeneous state in argon and helium are discussed and compared with theoretical predictions derived from a simplified mathematical model for plasma instability processes. It is shown that the instability of the discharge is due to a multistage plasma ionization. Experiments were carried out in helium and argon filled discharge tubes (3 cm diameter for helium; and 3, 5, and 13 cm diameter for argon), with pressures from 1 to 50 torr. Depending on the discharge parameters, the transition was either of the jump type (for a specific current), or unstable, fluctuating between the two states in a definite current range. The instability commenced at the lower current range limit along the decreasing volt-ampere characteristic, and the discharge stabilized into an inhomogeneous state only after the upper current limit was reached. The pressure effect on the magnitude of the transition currents varied for

different discharge tubes. The ionization nature of the discharge instability is strongly suggested by a correlation of the experimentally determined time necessary for the development of the instability process with the theoretical ionization time. Discharge instability was observed at the same current density in all discharge tubes under equivalent experimental conditions, and developed along the decreasing segment of the volt-ampere characteristic curve. The instability in helium commenced at higher current magnitudes than in argon. This is explained by a nonumiform energy level distribution in helium which necessitates higher concentrations for multistage ionization processes. Experiments performed by Novichkov (thesis, VEI im. V. I. Lenina, M. 1971) with an argon and cesium mixture revealed a decreased magnitude oftransition current. Because of the uniform energy distribution level in cesium, the multistage ionization commences at a much lower electron concentration. Oscillograms are given for voltage fluctuations and volt-ampere characteristics in the transition region for argon at 15 torr pressure.

Eydman, V. Ya. <u>On the electron-positron cascade process in a strong steady-state electric field.</u> ZhETF, v. 61, no. 5, 1971, 1737-1742.

A theoretical study of a self-sustaining cascade process in a constant strong electric field is described. Conditions giving rise to the periodic state of the system are discussed. A greatly simplified model of a narrow, one dimensional region with dense boundaries and a strong homogeneous electric field is considered. The assumption of a low particle concentration allows the treatment of the particles as relativistic. The interaction with gamma quanta is eliminated by the introduction of a magnetic field parallel to the electric field. A justification is given for the use of approximation equations for positive and negative charge concentration, as well as the homogeneous boundary conditions.

A solution to these equations is given and the results are analyzed for two cases: 1. When the particle annihilation is prevalent in the limit at $t \rightarrow \infty$, the system executes a periodic motion. 2. When particle production is predominant, system behavior depends on the initial particle concentration. With a relatively low initial concentration, the system produces damped oscillations; with a relatively large initial concentration, it produces time-increasing oscillations. The transition between the two states is characterized by an unstable periodic motion. An illustrative example is discussed. Conditions for damped or time-increasing oscillations and arbitray initial assumptions are also discussed. The authors point out that because of the magnitude of the electric field the results obtained could be applicable for pulsars ot terrestrial experiments.

Vagner, S. D., Yu. M. Kagan, and A. G. Slyshov. Electrical and optical measurements in a helium pulse discharge. Part I. OiS, v. 31, no. 6, 1971, 876-880.

The purpose of the experiment was to determine plasma parameters in a helium pulse discharge just before the onset of deionization and to analyze the energy level balance. Measurements were taken at 2, 5 and 10 torr pressure, using 0.8, 3.2, and 3.6a rectangular current pulses. A cylindrical discharge tube with cold electrodes was used. The duration of current pulses was 20 microseconds with 70 Hz repetition frequency. Longitudinal electric field E and electron temperature T_e were measured with two cylindrical probes. The anomalously high values of T_e are partially attributed to the vacuum gap created during the pulse passage. The method for measuring electron concentration was based on measurements of absolute intensity of the continuous spectrum generated during the deceleration of electrons on neutral atoms; the results are in

good agreement with theoretical calculations. A reabsorption method was used to determine the atomic concentration of helium at the low energy levels. Absolute intensity of a number of lines emitted from the energy levels with the principal quantum numbers 3, 4 and 5 was measured and the level balance for these p. q. n. was analyzed. In analyzing the level balance, the authors considered multistage electron exitation from the metastable and resonant levels as a level-populating process, and multistage ionization and spontaneous emission as a level destructing process. Due to the unavailability of some experimental and theoretical data a number of approximations was made in the level balance analysis, results of which are given in a tabulated form. Experimental results are given in Table I.

P, тор	i, а	$T_e \cdot 10^{-[illegible]}$, °K	E, в/см	5 $n_e \cdot 10^{-[illegible]}$, см$^{-3}$		8 $N_k \cdot 10^{-11}$, см$^{-3}$			
				формула (1)	форму-ла (2)	2^1S_0	2^1P_1	2^3S_1	2^3P_{012}
1	2	3	4	6	7	9	10	11	12
2	3.6	170	8	2.3	2.0	5	2.5	30	3
5	0.8	68	12	0.84	0.85	14	3	45	6
5	3.2	150	11	2.2	4.0	6.5	1	30	2.5
10	3.2	90	16	2.4	5.1	10	1.5	35	4.5

Table I. Comparison of probe and spectral values of charged particles. N_k = population of lower levels. 1- pressure, torr; 2- current, amp; T_e = electron temperature; 4- E = volt/cm; 5- n_e = electron concentration; 6- measured; 7- calculated; 8- N_k = atomic concentration; 9-12- helium energy levels.

Kichayeva, G. S., and M. L. Chepkalenko.
<u>Spectroscopic investigations of controlled discharges in a high-voltage vacuum commutator.</u> ZhTF, no. 10, 1971, 2151-2155.

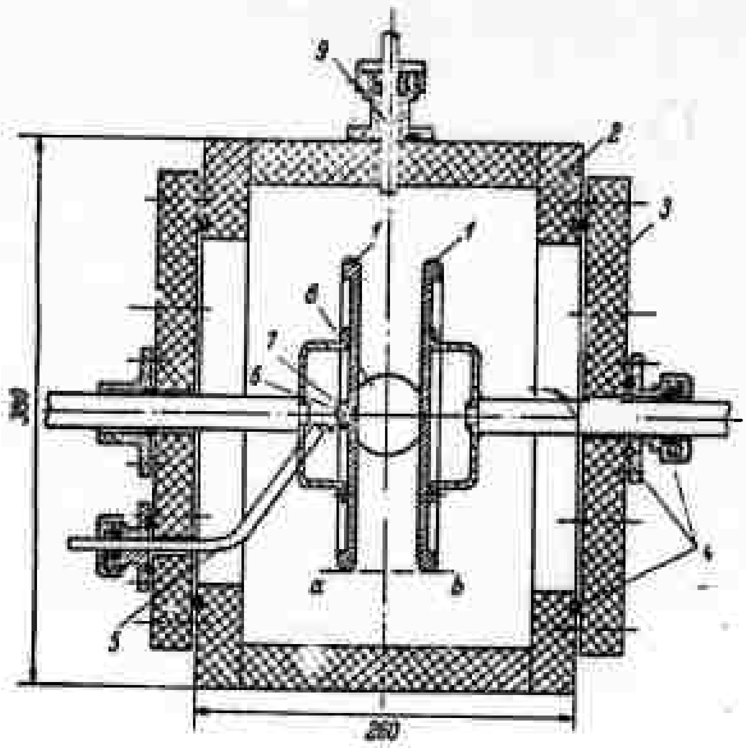

Fig. 1. Vacuum chamber.
1 - main electrodes; 2 - chamber;
3 - detachable flange; 4 - gaskets;
5 - ignition cable; 6 - insulated ignition plug;
7 - control electrode; 8 - port for evacuation;
9 - monitor tube. Dimensions in mm.

A controlled high-voltage pulsed discharge is investigated at comparatively large gaps (40 mm.) under conditions similar to the initial stages of a discharge in high-power vacuum commutators; specifically at discharge currents of a few kiloamperes of short duration (0.15-1.5 μsec). The emission spectrum of a controlled discharge between two flat 80 mm diameter electrodes, made with

different materials, was studied in a portable plexiglass chamber (shown in Fig. 1). The operating chamber pressure was held at (8-10) 10^{-5} torr by a vacuum pump. Discharge was initiated using an auxiliary needle-like control electrode of 1 mm diameter. A constant voltage of 40-45 kv was applied to the main electrodes. With an application of a ~25 kv pulsed voltage to the initiator the primary arc gap broke down in an aperiodic regime. The discharge current values were 1-7 ka and current pulse duration was 1.5, 0.6 and 0.15 μ sec. The emission discharge spectral composition was studied in the visible range. Long wave readings were taken on a spectro-projector in comparison with iron spectra. A table is given of line spectra obtained at a discharge current of ~7 ka and 1.5 μ sec duration, with ~500 a as ignition current for the following materials: cathode- Al, anode- Ni, control electrode- Cu, and insulating ignition plug- teflon. The electrode materials were all industrially pure metals. Studies were made of emission spectra in all gaps along the zone near arcing, and of the discharge spectra in the primary ignition gap for different electrode materials. All materials of the primary and control electrodes, initiation system, and insulators as well as the insulated vacuum chamber walls, contribute to the discharge development process when placed near the electrodes. Discharge development in the controlled gap was associated with the propagation of a plasma jet from the ignition region.

Bel'kov, Ye. P. Operation of arc-regulated spark gaps at a high repetition frequency of powerful current pulses. PTE, no. 1, 1972, 230-231.

The possibility was investigated of using arc-regulated spark gaps for commutation of current pulses of 20-100 ka amplitude, a duration of a few tenths of a microsecond and a repetition frequency to 50 Hz. Tests were conducted on the restoration of spark gap electrical stability, heating and destruction of electrodes, and unregulated operation. Restoration of electrical stability after the arc discharge was found to be closely correlated with the cooling of electrodes and of gas in the arc gap. The electrode materials (steel, molybdenum, metallo-ceramic composite AVM-30, or copper) did not significantly affect the rate of stability restoration, but the rate did decrease slightly with an increase of arc gap length. The restoration rate was also independent of the repetition frequency of current pulses as long as the energy release in the arc did not lead to a large temperature rise in the electrodes and the gas in the discharge chamber. The energy release in the arc discharge amounts to about several kw; this may sometimes produce strong local heating and melting of electrodes. Spark gap operation was tested in the regimes given in Table 1.

Table 1.

	Regime 1.	Regime 2.
1. Capacitance of energy storage, μf	0.12	0.5
2. Operating voltage, kv	50	50
3. Pulse repetition frequency, n, Hz	50	25
4. Current pulses:		
amplitude, I_m ka	44	65
duration T_i, μs	25	25
5. Average current in the spark gap i_{av}, a	7.4	8

The arc channel was not fixed at any particular point on the electrode surface and local heating was not observed at the regimes; the number of unregulated spark gap operations did not exceed 0.03%. Destruction of spark gap electrodes was tested at current pulses of 60-90 ka amplitude and 15-30 μs duration. The mean erosion rate of electrode materials per coulomb of energy dissipated in the arc was as follows: steel, ST3-0-0.85×10^{-4}g; AVM-30 composite- 0.7×10^{-4}g; molybdenum- 0.5×10^{-4}g; and brass- 0.5×10^{-4}g.

Smiyan, O. D. Stimulating the speed of a chemical reaction by the effect of a high energy electron beam. FiKhOM, no. 1, 1972, 163.

This work concerns the interaction of high energy electron beams with a solid, where the beam acts as a catalytic agent in certain chemical reactions in a liquid metal, melted by the beam. With the use of the MSKh-3 dynamic mass spectrometer and a high-speed movie camera the composition of material separated from a metal during bombardment by a 30-70 Kev electron beam was studied. In most cases the substance started to recede from the metal simultaneously with the beginning of the melting process. In certain cases, however, an "incubation period" was noted, varying in duration with changes in beam energy. A time curve is shown in Fig. 1 for CH formation according to the reaction

$$C + H \rightarrow \overset{e}{\overset{\downarrow}{CH}} \rightarrow CH^{+} + e \qquad (1)$$

in relation to the change of bambarding electron beam energy from 30 to 45 kev. CH formation time at 30 kev greatly exceeds that at E= 40-45 kev. CH formation at E = 30 kev is observed with a significant delay, but at E = 45 kev the combination takes place practically simultaneously with the melting of the metal.

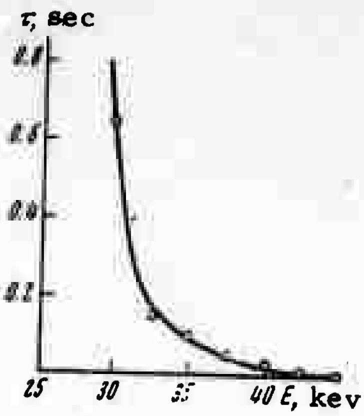

Fig. 1. Effect of electron beam bombardment on CH formation time.

Golov, A. A., G. N. Fursey, I. D. Ventova, A. D. Lebedev, and S. A. Valuyskiy. Comb-type field emitter. Otkr izobr, 19/72, no. 342241.

An author's certificate has been granted for a comb-type field emitter for use in various high current electronic devices. For ease of manufacture and reliability, the element is of unit construction, having individual emitter elements with a rectangular cross section.

Pranevichyus, L. I., G. N. Fursey, A. D. Lebedev, and I. Yu. Bartashyus. Liquefied field emission cathode. Otkr izobr, 19/72, no. 342242.

An author's certificate has been issued for a field emission cathode featuring a liquid metal surface. In order to reduce the cathode work function and increase the effective area of its emitting surface, the liquid metal is underlaid with a quartz plate, which is excited by an audio oscillator.

Krasovitskiy, V. B. Nonlinear theory of interaction between a restricted relativistic beam and a plasma. ZhETF, v. 62, no. 3, 1972, 995-1005.

The excitation of electrostatic oscillations by radially restricted relativistic beams is considered. This process yields data on the dynamics of beam particles in both longitudinal and lateral directions, as well as on maximum field amplitudes and beam radius levels at the moment of nonlinear stabilization. Nonlinear effects from plasma interaction with a monovelocity beam were computed using models in which the beam forms a succession of charged disc-shaped bunches moving through plasma and spaced one wavelength from each other. For a sufficiently wide beam,

$$a \gg \lambda \gamma_0^2 \qquad (1)$$

(a- initial beam radius; $\lambda = v_o/\omega_2$, v_o- initial beam velocity, and ω_2- plasma frequency), of parallel electron flight, the dynamics of instability is essentially the same as for an unrestricted beam in a strong linear magnetic field. Field density reaches

$$E^2 = 8\pi n_1 m v_0^2 \gamma_0^2 (\nu / 2)^{1/3} \qquad (2)$$

(where $\nu = n_1/n_2$, n_1 and n_2 are beam and plasma density) in the time $\tau_{\parallel} \sim (\gamma_0/\omega_2)\nu^{-1/3}$. For beams of radius less than $a \ll \lambda\gamma_0^2$, the presence of significant radial fields leads to a compression of unstable electron bunches in a lateral direction to a radius $R \sim (c/\omega_2)(\gamma_0/\nu)^{1/3}$ in the time $\tau_{\perp} \sim \omega_2^{-1}(\gamma/\nu)^{1/3}$ (without a significant change of linear beam velocity) and defocusing of beam passive particles falling at the initial moment of the field accelerating phase. A quasilinear theory on the interaction of a restricted relativistic beam with a plasma is discussed. Beam radius was found to be $R \sim c\gamma_0/\nu\omega_2$, at the end of the quasi linear stage of instability development. In the quasilinear case, focusing of each beam particle occurs under the effect of field resonance harmonics, with an energy density of $\nu n_1 m v_0^2$, which is less than a similar value for the hydrodynamical case, in which a single wave occurs. This lowers the focusing effectiveness and leads to an increase in beam radius for the kinetic case at the same beam and plasma parameters. However, the presence of a large number of waves results in uniform focusing of the kinetic beam along the complete length and prevents particle losses. The cited method of beam focusing into a plasma, according to the author, has application in controlled thermonuclear synthesis, where high current relativistic beams may produce an adequately dense plasma on the path to the target.

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5. Material Science

A. Abstracts

Raicheff, R. G., and A. R. Despich. The electrode kinetics of stress corrosion cracking of metals. DBAN, v. 24, no. 10, 1971, 1361-1364.

Known experimental data on stress corrosion cracking (S. C. C.) of metals in active and passive states are interpreted in light of an electrochemical mechanism proposed earlier by the authors [Compt. Rend. Acad. Bulg. Sci., v. 23, 1970, 1091]. Two sets of expressions were derived relating the rate V of crack propagation to the electro-chemical parameters. In good agreement with experimental data, the derived expression of V in the active region of potentials indicates that it depends on the $(i_o)_D/(i_o)_{M,S}$ ratio of the exchange current densities for depolarization and metal surface dissolution. This conclusion is supported by earlier experimental observations of S. C. C. in: (1) stainless steel in a boiling concentrated $MgCl_2$ solution; (2) Mg-Al alloys in aerated NaCl solutions in the presence of H_2O_2, as compared with the absence of S. C. C. in acid solutions with hydrogen evolution; and (3) low-carbon steel, compared to pure (99.8 and 99.9%) iron. The expression derived for a metal in the passive state indicates that initial V depends on the $(i_o)_{D,P}/(i_o)_{M,P}$ ratio of the exchange current densities for depolarization and dissolution of the metal surface at corresponding reversible potentials. The theoretical conclusion that the rate of V in a metal in a passivating medium is much faster than that in the same metal in an active state, e.g., hydrogen depolarized corrosion, is proven by known experimental observations. This conclusion applies only to initial crack development or to large specimens with few cracks. For a large number of cracks in small passive samples, the rate of V decreases in accordance with an equation similar to that derived for a metal in an active state. The electrochemical theory for S. C. C. of metals discussed has been successfully applied in calculating the approximate rate of S. C. C. and explaining S. C. C. differences between various systems.

Khannanov, Sh. Kh. Crack in a body with inclusions. FMM, no. 1, 1972, 217-219.

A theoretical study was made of crack propagation from a dispersed inclusion through the surrounding matrix of an alloy such as armco iron or aluminum silicide. Shear fracture is analyzed in a model with a cylindrical inclusion (Fig. 1a), which is subjected to tangential stress $\sigma_{yt} = \tau = \text{const}$. The problem is reduced to finding the function F(Z) of the

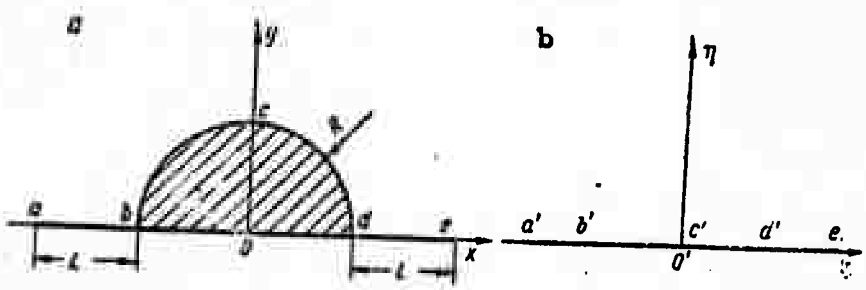

Fig. 1. Crack model: a - a body with a cracked cylindrical inclusion (symmetric half only is shown); the shaded area is the inclusion with a radius R; the abde intercept of x-axis is the extent of crack; L is the matrix crack length; b - area outside the inclusion after a conformal transformation. Primed letters designate points corresponding to the nonprimed letters on a physical plane.

complex variable Z = x + iy, which expresses elastic displacement and stress in the matrix with an absolutely rigid inclusion fractured along the y = 0 plane. The boundary conditions of F(Z) were formulated in terms of $dF/d\omega$ after conformal mapping, using the $\omega(Z)$ function, of the area bounded by the abcde line on the upper half-plane of the $\omega = \xi + i\eta$ complex variable (Fig. 1b). The solution of the boundary problem is

$$\frac{dF}{d\omega} = (-i\tau)(2R)\frac{\omega^2+1}{\sqrt{(\omega^2-1)(\omega^2-\beta^2)}}, \qquad (1)$$

where

$$\Gamma = \beta^2 \left[\frac{E\left(\frac{\pi}{2}, \frac{1}{\beta}\right)}{K\left(\frac{\pi}{2}, \frac{1}{\beta}\right)} - 1 \right], \qquad (2)$$

K ($\pi/2$, $1/\beta$) and E ($\pi/2$, $1/\beta$) are complete elliptic integrals of the first and second kind, and

$$\beta = \frac{1}{2}\left(\frac{R+L}{R} + \frac{R}{R+L}\right).$$

Formulas for stress concentration N at the ends of a crack $x = \pm (R+L)$ are also given. The formulas show that a crack in an inclusion can propagate to a low depth in the matrix, even if external stress is small. The stress formulas and the plot in Fig. 2, however, indicate that the condition of crack

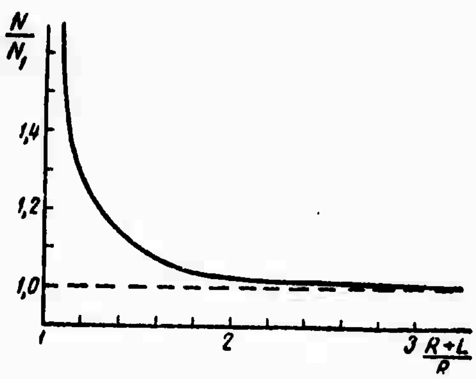

Fig. 2. N/N_1 versus $(R+L)/R$.

propagation at $L \geq R$ is hardly different from that in a homogeneous matrix. Crack propagation, i.e. body fracture, from a rigid inclusion in the matrix is found to be unlimited only when the inclusion dimensions and the Griffith crack are nearly equal.

Khannanov, Sh. Kh. Shear crack initiation.
FMM, no. 1, 1972, 185-188.

The equilibrium of a body with an angular cut and an open Burgers contour along the cut is analyzed by the method of conformal transformations. The generalized case when an external shear stress τ causes an elastic displacement V along the t axis normal to x-y plane is examined (Fig. 1). The displacement acquires an increment B, i.e. screw dislocations appear in the cut, with the total Burgers vector equal to B. Using ζ as a conformal mapping of Z and assuming $Z = \omega(\zeta)$, formulas were derived for

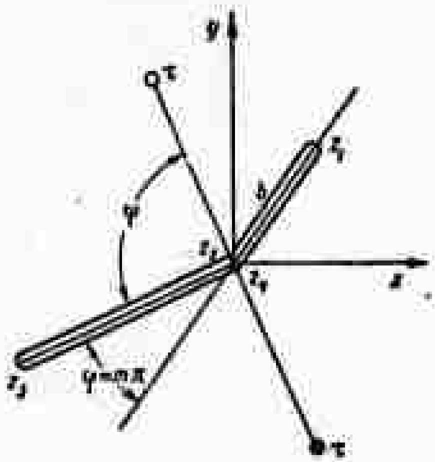

Fig. 1. Elastic body with angular cut:
Z_1, Z_2, Z_3, Z_4 - angular points of the cut,
$\varphi = m\pi$ -angle between two arms of the cut;
arm lengths equal a and b, respectively,
ψ -angle of application of external shear stress τ, x and y - rectangular coordinates.

the shear stress concentrations $K_3^B(\zeta_1)$ and $K_3^B(\zeta_3)$ brought about by dislocations in the ζ_1 and ζ_3 points. The formulas

$$K_3^B(\zeta_1) \to \frac{BG}{2\pi\sqrt{2R}}\left(\frac{1-m}{1+m}\right)^{m/2}; \quad K_3^B(\zeta_3) \to -\frac{BG}{2\pi\sqrt{2R}}, \quad 4R \to a \tag{1}$$

where G is the shear modulus, a is the length of piled up dislocations $b/a \to 0$, and $m = \varphi/\pi$, were used to formulate the condition of crack initiation at the tip of piled up screw dislocations. The condition

$$(B\tau)^0 = 2\gamma\left(\frac{1+m}{1-m}\right)^m \tag{2}$$

where γ is the surface energy, appears to be less rigid at $\varphi = 0$, when the crack surface coincides with the glide plane of dislocations. This qualitative conclusion is in agreement with the similar findings of other cited authors.

Krestin, G. S., L. L. Libatskiy, and S. Ya. Yarema. Stressed state of a disc with diametric crack. F-KhMM, no. 2, 1972, 69-74.

A mathematical solution is presented to the problem of crack propagation resistance in a stressed disc of radius R with a 2ℓ long central crack in the OX-axial direction. Normal and tangential stresses are created by application of arbitrary symmetric or antisymmetric loads to the upper or lower edges of the crack. The stressed state of the disc is determined by series parametric expansion of two kernels of a set of integral equations, using $\lambda = \ell/R$ as a parameter and limiting the series to the λ^{12} terms. Solution of the resulting single integral equation determined the shift functions of the crack edges. The formulas for these functions together with those for the two complex potentials in a solid disc under a given load completely define the stress state of a disc with a crack.

Using these formulas, the stress intensity factor k_k was expressed by

$$k_k = R \int_{-\lambda}^{\lambda} p_k(t)\, k_k^{*}(t)\, dt. \tag{1}$$

where p_k is a random function $p_k = p_k(\xi)$, $\xi = x/\ell$, and $t = \xi_0 \lambda$. The factors k_1 and k_2 were calculated in two particular cases: (1) for two normal (k_1) and two tangential (k_2) equal and opposite concentrated forces applied to the crack edges at a point $\xi = \xi_0$ (Fig. 1), and (2) for a normal and a tangential uniform load. In the first case, the estimated error of the k_1 calculation was a maximum of 2% for $\lambda \leq 0.7$. The critical load K_{Ic} is determined by the formulas

$$k_1 = K_{1c} \text{ or } \frac{2}{\sqrt{3}} k_2 = K_{1c}. \tag{2}$$

and variations in K_{Ic} versus λ are shown in Fig. 1 and 2, respectively, for the first and second case.

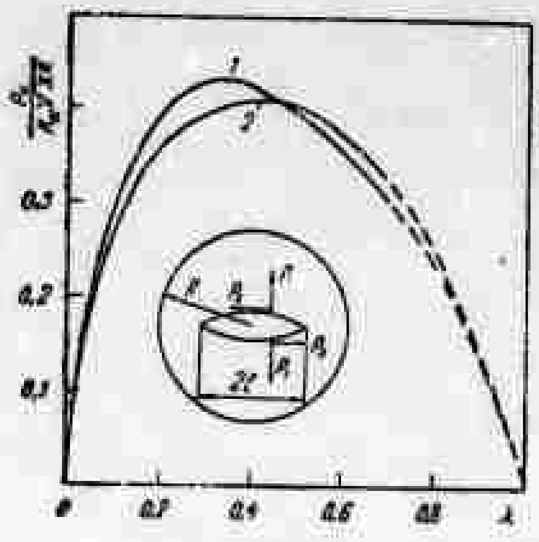

Fig. 1. Critical normal (curve 1) and tangential (curve 2) concentrated loads versus crack length

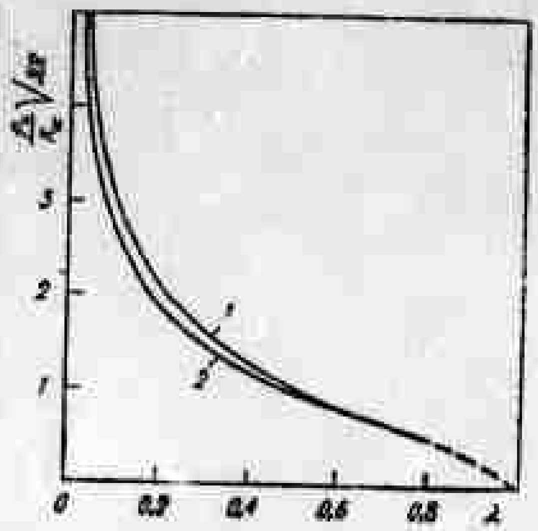

Fig. 2. Critical normal (curve 1) and tangential (curve 2) distributed loads versus crack length

Pidstryhach, Ya. S., and V. A. Osadchuk.
<u>On the problem of the state of stress in a closed cylindrical shell with a crack.</u>
AN UkrRSR. Dopovidi, Seriya A, no. 1, 1972, 79-83.

A system of integral equations is derived and solutions are proposed for stress parameters in a cylindrical shell with a crack. The authors first consider the case of a circular cylindrical shell with geometrically small deformation given by the tensor components of distortion and elastic deformation. For this case a system of general differential equations is set up and partial solutions in terms of linear differential operators of at most seventh order are given. For a particular distortion field and certain assumptions on shell parameters a complete solution is obtained. These results are used in setting up and solving the problem of a closed infinite cylindrical shell with a crack and under a symmetrical load. The system of integral equations is derived by requiring that the deformations (load and distortion field) and the corresponding resultant forces along the imaginary crack line in the shell without the crack satisfy the symmetry and boundary value conditions of the cracked shell. By using standard methods of integral equations, the solution of this system is reduced to the solution of Fredholm equations of the second kind. For small values of λ, the solution of the Fredholm equations is in the form of an infinite series. The forces and moment along the extended crack line and near the end of the crack are obtained by solving the singular part of the kernel given in terms of the solutions to the Fredholm equations.

Ratner, S. B., The effect of loading on the fracture and deformation rates of polymers. MP, no. 2, 1972, 366-368.

A general formula (1)

$$U = U_0 - a\sigma + b\sigma^2$$

is introduced to describe the energy of activation U for fracture, relaxation, and creep processes in polymers under load σ. These processes were previously described by a different formula. Equation (1) can also be written as

$$U = U_0 - \gamma\sigma \quad (2)$$

where $\gamma = dU/d\sigma$ is the structure-sensitive factor. Creep experiments with polyethylene conducted by the author and V. P. Yartsev led to the establishment of a linear relationship between γ and elongation ϵ (Fig. 1).

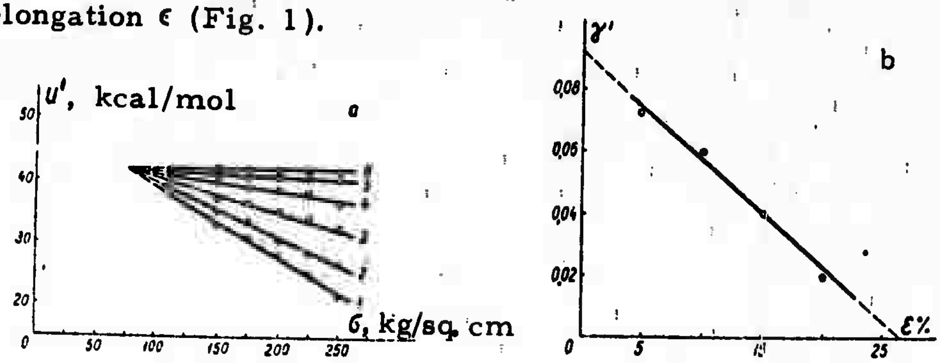

Fig. 1. The effect of a given creep in polyethylene on U(a) and γ(b). ϵ = 5% (1), 10% (2), 15% (3), 20% (4), 25% (5), neck (6).

The behavior of γ indicates, in general, the effect of loading. Eqs. (1) or (2) qualitatively describe creep and creep rupture of a polymer. They also describe earlier experimental data on strength of polymer coatings, energy of activation of rubber fracture, rupture of welded joints, and abrasion of elastomers. It was concluded that the relatively simple Eq. (1) adequately describes the effect of strain on critical loading time for different classes of polymers.

Soshko, A. I., Nature of crack propagation in PMMA from deformation in active media. F-KhMM, no. 6, 1971, 31-34.

The propagation pattern of a pre-existing crack in a disc-shaped sample was observed in liquid media and under various applied constant loads P. Microscopy, photography, and high-speed motion pictures were used for observations. A liquid alcohol of a homologous series was introduced into the crack of a loaded sample. Crack propagation started when the liquid first contacted the solid in the crack tip. It was shown that P_{min} necessary for initiation of crack propagation is directly proportional to the number of CH_2 groups or C atoms in the alcohol molecule. The P_{min} in alcohols was much smaller than in air. The kinetics of crack propagation under a constant load is shown in Fig. 1.

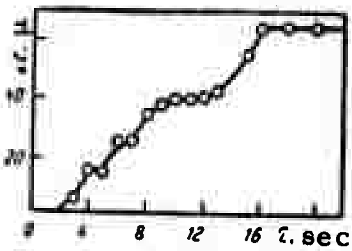

Fig. 1. Crack elongation $\Delta \ell$ versus time under P = 1 kg load.

Under a load higher than P_{min}, the cracking intensity decreases proportionally to the increase in the number of C atoms per alcohol molecule, and $P_{crit.}$ consequently decreases. Two patterns of crack development were observed in all media studied: further propagation or branching at the tip of the main crack, depending on the applied load. The cited observations were interpreted in the light of chemical

and physical interactions between the low-molecular weight medium and the macromolecular polymer. The effect of the medium on the fracture pattern and strength of PMMA is basically attributed to intermolecular interactions. Fracture is accelerated for surface interactions, or decelerated, as the result of macromolecule orientation in the bulk sample. Branching of the main crack under a load $>P_{min}$ is assimilated to interpack diffusion of the liquid and is dependent on localization of elastic energy at the tip of the main crack. The occurrence of either accelerated propagation or branching of the main crack depends on the magnitude of stress concentration at the tip.

Libatskiy, L. L., Fracture of a disc with an external crack by concentrated forces. F-KhMM, no. 6, 1971, 89-92.

A mathematical analysis is given of mechanical characteristics of fracture toughness of a solid circular disc with an external crack. The substitution of an approximate solution into an integral equation describing the stressed, deformed state of a solid circular disc with a crack terminating on its circumference, gives a general expression for tension in the disc caused by an external load applied along the crack. After determination of the unknown coefficients by collocation method, the limiting value for the external load as a function of destruction energy and Young's modulus is obtained. With the assumption of uniform concentrated forces applied at points symmetrically located with respect to the crack, a particular expression for the tension in a solid disc is given. The cited equations are used to compute critical magnitude of concentrated forces as a function of normalized crack length. Final results are presented graphically in Figs. 1-3.

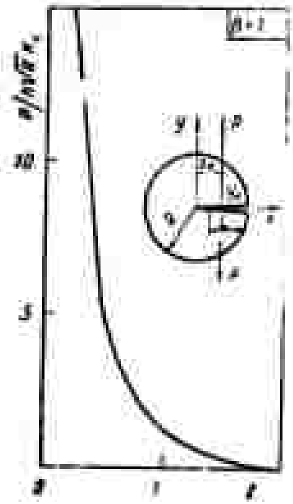

Fig. 1

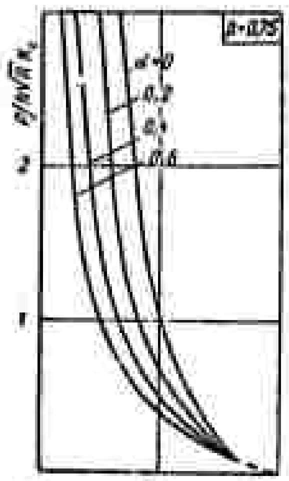

Fig. 2

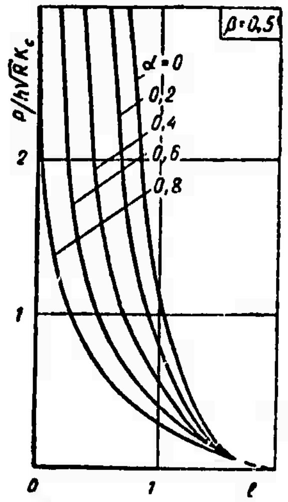

Fig. 3

Critical load vs. α and β.

$\alpha = x_0/R$; $\beta = y_0/R$; P = applied external force; h = disc thickness; R = disc radius; K_c = Irvine's constant.

Lebedev, D. V., and B. M. Ovsyannikov. Study of crack propagation in prismatic specimens with unilateral grooves under fatigue loading. F-KhMM, no. 6, 1971, 27-30.

A theoretical and experimental study was made of the relationship between the stressed state and morphology of crack propagation from elastic deformation under fatigue loading. Analysis of the stressed state created near a groove by bending a prismatic specimen with selected parameters gave the values 3.4 for the geometric stress concentration factor K_T and 25 kg/mm^2 for bending stress σ_1 at the edges of a 2 mm deep groove with a 0.25 mm radius at the edge. The stressed state was studied experimentally by an optical polarization method in optically active specimens of similar geometry, which initially did not exhibit an optical effect. The optical data (Fig. 1) revealed that the absolute value of σ_1 max. (at the groove edges) is equal to

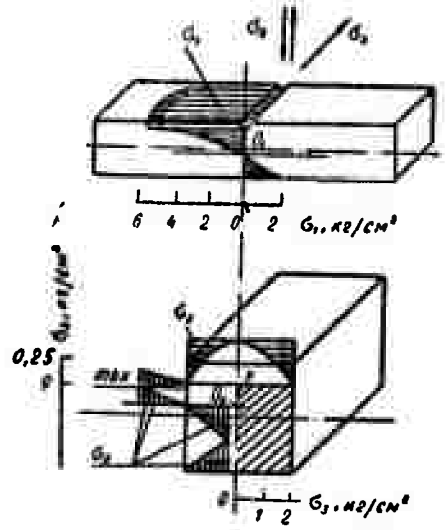

Fig. 1. Distribution and qualitative relationship of the normal stresses from elastic bending of an optically active specimen, σ nominal = 1.77 kg/sq. cm.

3.3σ nominal, in good agreement with the theoretical K_T. The tensile stresses σ_2 and σ_3 are maximum at a point k located at 0.2 - 0.5 mm below the bottom of the groove. The point K is the most probable site of the initial fractures which subsequently develop into a crack emerging on the surface. Morphology of the crack propagation was also studied by micrography and microhardness measurements of successively polished prismatic specimens of type X21H5AG7 (EP-222) austenitic steel. The micrographs show that the surface crack is branched with plastic deformation tracks along the crack, while the crack in the middle of a specimen is straight, without plastic deformation tracks. The cracks in intermediate microsections exhibit a profile intermediate between the cited extremes. Microhardness along a straight crack was not significantly different from that of the matrix, but increased progressively to a maximum value near the surface crack. Differences in internal and surface crack profiles are explained in terms of the different stressed states inside the specimen and on its surface, where $\sigma_3 = 0$.

Savruk, M. P., Stresses in a plate with an infinite array of parallel cracks under a symmetrical load. F-KhMM, no. 6, 1971, 104-106.

A theoretical analysis is presented of the stressed state in an infinite elastic plate with a periodic array of parallel cracks, $(-)\ell \leq X \leq \ell$, $Y = 2\,nh$, where $n = 0, \pm 1, \pm 2 \ldots\ldots$ The stressed state of such a plate under a $p(x)$ load applied to the edges of a crack is expressed by the function $\varphi(x)$ describing crack geometry ($x = X/\ell$). The function $\varphi(x)$ is determined, with an approximation equal to or better than 10%, by solving the integral equation

$$\int_a^b \frac{\Phi(\eta)\,d\eta}{\eta - y} = \pi f(y) + C, \quad a < y < b. \tag{1}$$

where the variables are

$$\eta = e^{A\xi},\ y = e^{Ax},\ a = e^{-A},\ b = e^{A},\ \varphi\left(\frac{\ln \eta}{A}\right) = \Phi(\eta),\ 2P\left(\frac{\ln y}{A}\right) = f(y), \tag{2}$$

$A = 2\pi\lambda$, $\lambda = \ell/h$, and $P(x) = \ell^2 \int p(x)\,dx$.

The stress intensity factor k at a crack tip is formulated in the cases of: 1) equal normal forces applied in opposite directions to the crack edges at a point $x = x_0$, and 2) a uniformly distributed load $p(x) = (-)p = \text{const}$. In the latter case,

$$k = p\sqrt{\frac{l\,\mathrm{th}\,\pi\lambda}{2\pi\lambda}}. \tag{3}$$

Previously, the asymptotic formulas

$$k = p\sqrt{\frac{l}{2}}\left[1 - \frac{1}{8}(\pi\lambda)^2 + \frac{3}{128}(\pi\lambda)^4 + O(\lambda^6)\right] \tag{4}$$

and

$$k = \frac{p\sqrt{l}}{\sqrt{2\pi\lambda}}. \tag{5}$$

were derived for a uniform loading for small and large λ values, respectively. Assuming that $\sigma x\,(x, 0) = \sigma y\,(x, 0)$ along the uniformly loaded crack (the case of very small λ values), then

$$k = p\sqrt{\frac{l\,\mathrm{th}\,\frac{\pi\lambda}{2}}{\pi\lambda}}. \tag{6}$$

The λ versus k plots (Fig. 1) calculated from Equations (3) - (6) indicated that the cited approximation of the $\varphi(x)$ function is

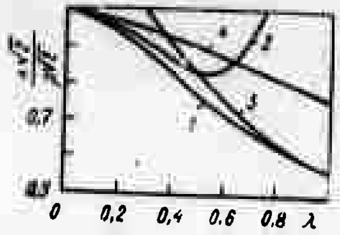

Fig. 1. The k versus λ plots: 1, 2, 3, and 4 calculated from (3), (4), (5), and (6), respectively.

sufficient at any value of the λ parameter. At $0 \leq \lambda \leq 0.2$ and $0.8 \leq \lambda \leq \infty$, the relative error of k determination by Equation (3) is 1% maximum.

Panasyuk, V. V., and A. P. Datsyshin, Limit equilibrium in a half-plane with an arbitrarily oriented crack extending to the plane boundary. F-KhMM, no. 6, 1971, 102-104.

Analysis is made of tensile stresses p_i, arbitrarily distributed in an elastic half-plane with a crack ℓ emerging on the plane boundary at an angle α (Fig. 1). The problem of stressed

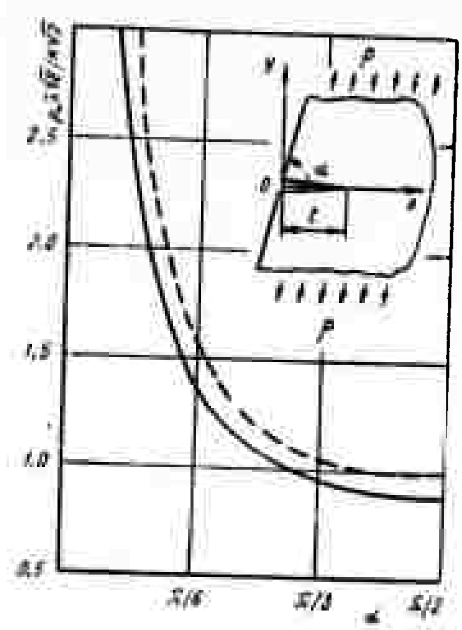

Fig. 1. Critical tensile force p_* versus crack inclination α. Continuous line-crack ℓ; broken line-crack 2ℓ.

state determination is reduced to approximate solution of a set of two singular integral equations in complex form. Using the method of collocations, the integral equation is reduced to a set of 2m algebraic equations which are solved for 2m unknown factors b_n, c_n. These factors were determined for forces p uniformly distributed at infinity

and oriented parallel to the half-plane boundary (Fig. 1). The relationship between stress intensity factors k_1, k_2, at the crack edges was then formulated using known formulas by

$$k_1 - ik_2 = -p\pi\sqrt{2l}(c_1 - ib_1). \qquad (1)$$

Using the theory of crack propagation, the angle β_* of initial crack propagation and the critical tensile force p_* were given. respectively, by

$$\beta_* = 2\,\mathrm{arctg}\,\frac{c_1 \pm \sqrt{c_1^2 + 8b_1^2}}{4b_1} \qquad (2)$$

and

$$p_* = -\frac{4K}{\pi^2\sqrt{l}}\left[c_1\left(3\cos\frac{\beta_*}{2} + \cos\frac{3\beta_*}{2}\right) - 3b_1\left(\sin\frac{\beta_*}{2} + \sin\frac{3\beta_*}{2}\right)\right]^{-1}. \qquad (3)$$

where K is the constant of the material. Numerical calculations for m= 3, 4, 5 and the plots of p_* (Fig. 1) and β_* versus α showed, as expected, that the boundary effect increases with the decrease of α. At $\alpha < \pi/4$, the correction due to the boundary effect is ~ 20% for both p_* and β_*. At $\alpha = \pi/2$, p_* coincides with the data obtained earlier by Datsyshin [F-KhMM, 1969, no. 6].

Summm, B. D., Ya. Mukhammed, N. V. Pertsov, T. P. Malygina, and P. V. Kozlov. <u>Crack propagation in stressed polyethyleneterephthalate in the presence of organic liquids.</u> F-KhMM, no. 2, 1972, 33-37.

In an experimental study of crack propagation kinetics, 0.3 mm thick nonoriented and 0.1 mm thick oriented amorphous polyethyleneterephthalate (PETP) films were stretched at room temperature at a rate of 108 mm/min. to pre-determined elongations. Both ends of the elongated film were rigidly fastened, and an area on one side of the film was wetted by an organic surface-active liquid. Crack propagation was recorded with a motion picture camera and crack length l was measured. The wetting agents were selected from the class of compounds containing the same >C = 0 group as the PETP molecule. Typical kinetic curves obtained (Fig. 1) revealed three successive propagation phases:

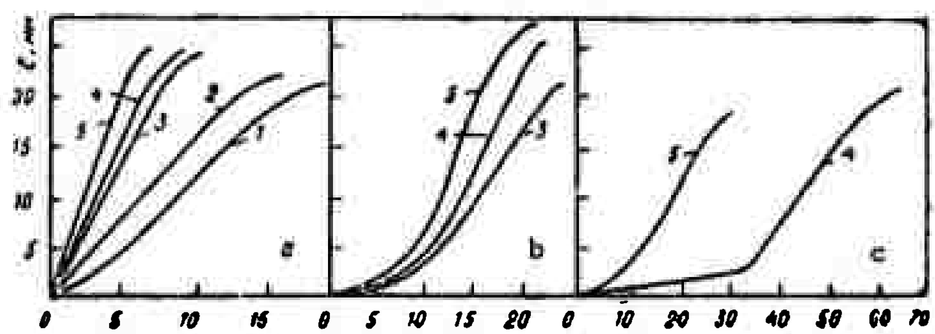

Fig. 1. Crack length (l) vs. propagation time (t) in PETP in the presence of acetone (a), ethyl acetoacetate (b), and acetic acid (c) at applied loads of 1-0.55; 2-1.1; 3-1.65; 4-2.2; or 5-2.9 (kg/sq. mm).

a relatively slow initial phase which sometimes was undetected, a second more rapid phase of the most substantial propagation, and a final propagation phase with a steadily decreasing rate.

The generation of a main line crack was observed in the initial phase. In the second phase, the main crack propagates at a rate dependent on the applied load. A narrow, branched crack is formed at small loads; at large loads, a wide crack propagates without branching. The load-dependence of the propagation rate is connected with crack tip formation. The crack propagates farther at the same rate at which liquid reaches the tip. This mechanism of crack propagation differs from that in unwetted PETP and is similar to that in metals in the presence of adsorption-active melts. The similarity with metals was confirmed by an experimentally established analogous crack propagation pattern in PETP wetted with liquids of different viscosity. Linear $\ell(t)$ dependence is related to the hydraulic counter-pressure generated by the narrow tip and confirmed by experiments in the presence of acetone with a 5-25% water admixture. Crack propagation in oriented PETP in the second phase was significantly slower than in the nonoriented samples.

Kit, G. S., and O. V. Poberezhnyy, Equilibrium limit in a brittle solid with a disc-shaped crack under stress and temperature effects. F-KhMM, no. 2, 1972, 63-69.

A theoretical solution is presented to the problem of limit equilibrium stress in an infinite elastic isotropic body with a thermally insulated crack of radius a. The stressed state is brought about by simultaneous application of external forces p and a stationary thermal source of power q assigned to a continuous body. The problem is treated as the sum of three problems which are solved successively. The aim of the first problem was to define the stressed state of a continuous body and find the symmetric and antisymmetric stress components in area S of a crack coincident

with the z=0 plane, where z is a coordinate in the (r, φ, z) cylindrical system, with the origin in the crack center. This problem was solved by formulating the corresponding stress intensity factors k_1 and k_2 and the elastic stress tensors $\sigma_{\beta\beta}(x, \beta)$ and $\sigma_{x\beta}(x, \beta)$ near the crack contour in the local polar coordinate system x, β (Fig. 1).

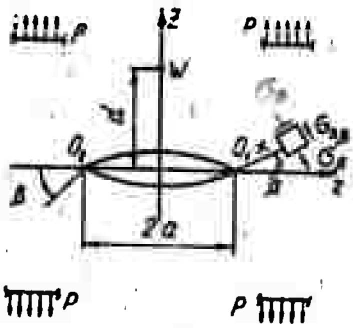

Fig. 1. Diagram of the stressed state near the crack contour.

Using the formulas of $\sigma_{\beta\beta}(x, \beta)$ and $\sigma_{x\beta}(x, \beta)$ the problems of forces applied to the crack surface and the thermoelastic state brought about by perturbation of the temperature field were solved by formulating the conditions defining the critical load p* and temperature factor q* at which the crack attains limit equilibrium. The design p* and q* values are given by

$$p_* = \min\{p_*^{(1)}, p_*^{(2)}\},\ q_* = \min\{q_*^{(1)}, q_*^{(2)}\}. \quad (1)$$

where indexes 1 and 2 denote the critical values of maximum tensile stress normal and tangential to the crack surface. With the cited procedure, the limit equilibrium state of the body with a crack is analyzed for a tensile force p applied normally to the crack plane and a stationary heat source q in the point r=0, z=d (Fig. 1). Variations of $p_*^{(i)}$ versus η and q* versus η * at different δ =d/a values are presented graphically for the specific cases of an open and a closed crack, respectively. In the latter case, allowance is made for the friction between the crack edges.

Malinochka, Ya. N., G. Z. Kovalchuk, and Ya. L. Troskunov. Reasons for formation of internal cracks in 20 KhNR steel ingots. IAN Metally, no. 1, 1972, 164-169.

Comparison of 3.5 ton 20 KhNR steel ingots cooled by two different methods revealed a greater number and larger size of cracks in the steel poured under thermally insulating slag. Size and distribution of internal cracks in the type of ingot was studied, and a detailed analysis of metal structure and composition around the cracks was performed. Microanalysis of the region around the cracks revealed the presence of a boride lattice or boron-carbide complex along the austenite granules. A boron-carbide film was frequently observed at the end of the cracks. It was found that the cracks start and propagate along the brittle boundary between the austenite granules and boron-carbide lattice at the time of itsformation (crystallization of F_2B from the supersaturated austenite) at relatively low temperatures. The formation and propagation of cracks is caused by the tensions due to the nonuniform cooling of the various ingot layers. The nearly horizontal crack distribution is explained by the elongation of the granules in the direction of preferred dendrite growth, and also by the pressures in the predominantly vertical direction. The distribution of boride (Fe_2B) phase is largely determined by dendritic liquation of boron. The presence of carbide along the austenite granule boundary could not be satisfactorily explained; however, it was established that it definitely facilitated the crack formation. Tests were run to determine boride solubility during ingot heating. Complete solubility occurred in 30 minutes at 1100°C. It was found that the rapid air cooling (5-6 deg/min) of steel precludes the separation of boride. However, during slow cooling (1 deg/min) the crystallization of boride takes place along the primary austenite granules as well as around sulfide impurities.

Georg, E. B., Yu. K. Rulev, G. F. Sipachev, and M. I. Yakushin. Experimental study of ablation boundary layer in specimens under simultaneous action of convective and radiative heat fluxes. MZhIG, no. 2, 1972, 25-29.

The ablation boundary layer in asbestos-reinforced plastic cylindrical specimens with a spherically blunted nose was studied in an air plasma jet produced by a high-frequency electrodeless discharge. The discharge generated a 37 mm diameter plasma jet at 1 kg/cm^2 pressure with Reynolds number of 100 and a 30 m/sec velocity. The plasma, boundary layer, and specimen emission spectra were recorded simultaneously on a photographic plate by means of an optical system including an ISP-51 prismatic spectrograph. Plasma jet interaction with the studied material was recorded by motion picture camera at a speed of one frame/second. A sharp boundary was detected between the specimen and the boundary layer. The visible emission spectrum of the latter exhibited characteristic lines of the elementary constituents of the original material. The boundary layer emission intensity in the 3838-6483Å spectral range was comparable to or higher than that of the plasma. The temperature profile across the boundary layer (Fig. 1) was determined near the

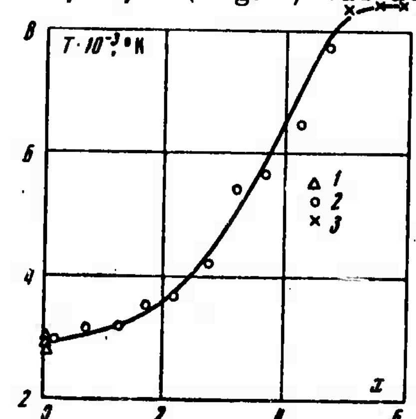

Fig. 1. Temperature of ablation surface (1), temperature profile across the boundary layer (2), and plasma temperature (3).

critical point from the spectral measurements (CN lines) of vibrational temperature of vapors in the boundary layer. The measurement accuracy was ±400°K. The spectroscopically measured plasma temperature was 8,500 ± 150°K and the true temperature of the ablation surface was 2,600 ± 200°K, where the latter was determined from measurements of the surface brightness. Temperature profile and IR motion pictures indicate that the boundary layer is separated from the specimen surface. According to the proposed model of the ablation boundary layer, gas formed by thermal destruction of the specimen is injected through the gas-body interface normal to the body surface. The convection component of heat flux is evaluated on the basis of this model. It was concluded that a decrease in convection by injection of the gaseous ablation products into the boundary layer is the principal mechanism of heat absorption.

Lutkov, A. I., B. K. Zymov, and V. I. Volga. <u>The relationship between thermal and electrical conductivities of graphite</u>. I-FZh, V. 22, no. 5, 1972, 932. (Annotation).

An attempt to correlate thermal conductivity λ with electric resistivity δ of graphite at high temperatures is described. Many researchers previously noted that the $\lambda \times \delta$ product is constant to a certain degree, but only at room temperature.

Experimental λ and δ data in the range 80 - 2,500°K range are given and the $(\lambda \times \delta)$ values are calculated for artificial graphites with 1.0 - 2.26 g/cm^3 specific weights. At a low temperature, the $(\lambda \times \delta)$ of individual graphites varied significantly. At room temperature, $(\lambda \times \delta)$ was nearly the same for the graphites studied. At $T > 1,500$°K, $(\lambda \times \delta) = 0.34 - 0.38$ V^2/degree and is independent of temperature for all graphites studied with the exception of those with lowest (1.0 g/cm^3) and highest (2.26 g/cm^3) specific weights.

Voronin, V. I., and A. Ye. Blazhkov. Thermal boundary layer on a noniso-thermal plate. IVUZ Aviatsionnaya tekhnika, no. 1, 1972, 119-123.

The equation of energy of a compressible laminar boundary layer on a semi-finite plate with different local boundary conditions is analyzed. It is assumed that the $0 \leq \xi \leq 1$ area of the leading edge, where $\xi = \xi / \ell$ and ξ is the longitudinal coordinate, is cooled to a constant temperature T_{wo}, and its equation of energy is solved by the known Crocco integral. Using this integral and a Laplace transform, the equation of energy of the heat insulated section $1 \leq \xi \leq \infty$ of the plate is approximated with a relatively small error by

$$t(1-t)\frac{d^2i^*}{dt^2} + \frac{2}{3}(1-t)\frac{di^*}{dt} - pi^* = -p(a + b\sqrt[3]{t}). \tag{1}$$

where the variable $t = u^{-3}$, p is the Laplace variable, a and b are the constants in the Crocco integral i, and * denotes the function in the transform space. In general form the (1) approximation, which also describes the boundary layer in the $1 \leq \xi \leq \infty$ section, is solved for i^*

$$i^* = AF(\alpha, \beta, \gamma; t) + Bt^{1-\gamma}F(\alpha_1, \beta_1, \gamma_1; t) + a + i_2^*. \tag{2}$$

where $F(\alpha, \beta, \gamma, t)$ and $F(\alpha_1, \beta_1, \gamma_1, t)$ are hypergeometric functions, i_2^* is the particular solution of (1), A and B are the constants of integration, which are determined from the boundary conditions. Thus, B = 0 and A is expressed in terms of the hypergeometric functions and the logarithmic derivative of the Euler gamma-function Γ. Using (2), the temperature T_w of the heat-insulated surface of the plate is expressed through the Γ functions

$$\frac{T_w - T_{w0}}{T_e - T_{w0}} = 1 - \frac{1}{9\Gamma^2(2/3)} \sum_{n=1}^{\infty} \frac{6n-1}{(n!)^2} \Gamma^2\left(\frac{3n-1}{3}\right) \frac{1}{\xi^{\frac{(6n-1)^2-1}{36}}}. \tag{3}$$

This method of T_w determination on a plate with a cooled nose is extended to the case of a surface with heat exchange. The method is illustrated by the example shown in Fig. 1.

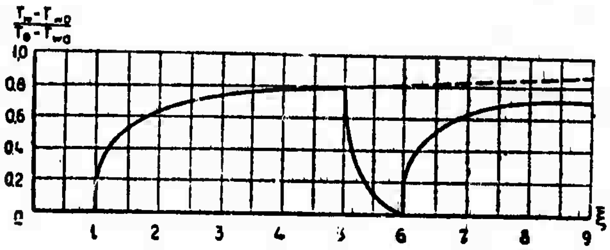

Fig. 1. Temperature distribution along a plate with cooling of the $5 < \xi < 6$ area according to the formula $q_w = 2(T_o - T_{wo})$.

Fateyeva, N. S., and L. F. Vereshchagin. Melting curve of molybdenum up to 90 kbar. ZhETF P, v. 14, no. 4, 1971, 233-235.

A test is briefly described in which the melting curve of pure Mo under high pressure was measured by an optical method described earlier by the authors. The method is based on simultaneous determination of the radiation intensity ratios I_1/I_2 and I_2/I_3 of two pairs of narrow spectral regions, and their subsequent comparison with Planck's law. The experimental T(P) plots of Fig. 1 can be presented by the linear equation

$$T_M = 2883 + 0,8 \cdot 10^{-3} P \qquad (1)$$

where T is melting point in ^{o}K and P is the pressure in bars. The probable error is $\pm$% for both T and P measurements. A similar experiment was reported by Fatayeva et al on melting characteristics of graphite under high pressure [Explosion Effects Report No. 2, p. 58].

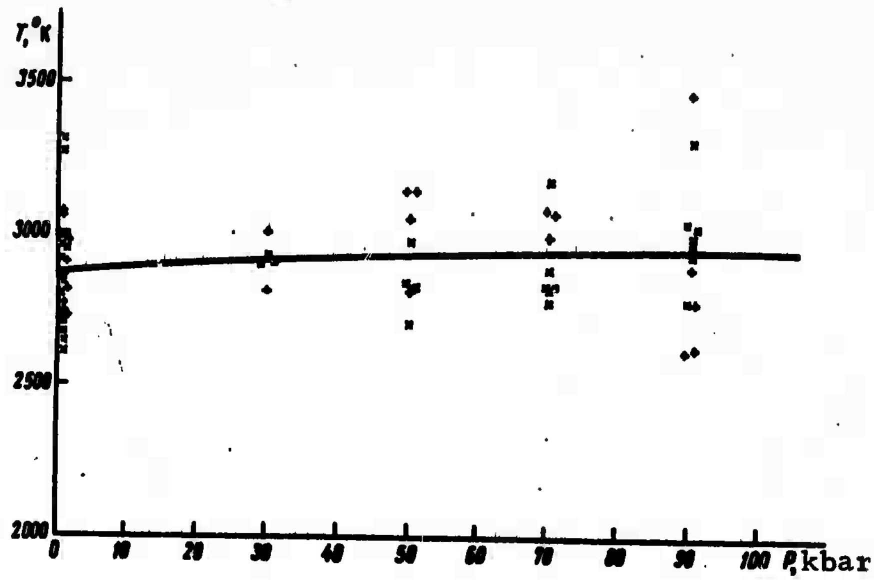

Fig. 1. Melting curve of Mo up to 90 kbar, calculated from all experimental points.
+ - temperature data of I_1/I_2 measurements,
x - temperature data of I_2/I_3 measurements.

Vereshchagin, L. F., Ye. V. Zubova, and G. L. Aparnikov. Evaluation of the normal pressure distribution in the "Bridgman anvils" type of apparatus by a shear stress method. DAN SSSR, v. 196, no. 5, 1971, 1057-1060.

An evaluation was made of the pressure distribution P in thin (thickness h = 0.05 - 0.18 mm) copper, lead, and pyrophyllite discs, pressurized at 20-300 kbar in Bridgman anvils of small diameter (D). Torque M was measured at different pressures, and shear stress σ_m was calculated from the formula

$$\sigma_m = 3M / 4\pi a^3. \qquad (1)$$

The plots of σ_m versus P show that P_a on the edges of a sample increases with the increase in D/h ratio. The experimental D/h ratios were in the 13-60 range, hence corresponded to the type 1 distribution of P (Fig. 1) The P distribution was evaluated approximately from

$$P_a/P_0 \approx \sigma_a/\sigma_0 = (2\sigma_{cp} - \sigma'_{cp})/(3\sigma'_{cp} - 2\sigma_{cp}). \qquad (2)$$

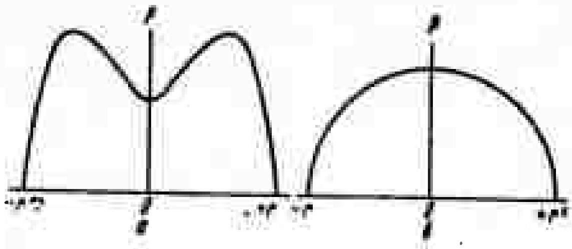

Fig. 1. Presumable pressure distribution: a - type 1, b - type 2.

on the assumption that the $\sigma(P)$ function and the σ versus radius r diagram are linear. The $\sigma(r)$ diagram of Fig. 2 shows that $\sigma_m > \sigma'_m$, where σ'_m corresponds to $D/h \approx 15 - 20$, hence $P_a > P_o$. This was confirmed by the fact that h on the edges of all samples was smaller than in the center. Using (2), P_a was

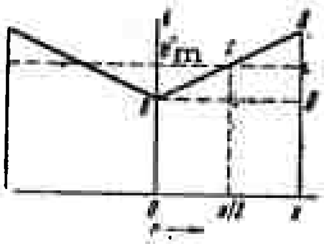

Fig. 2. Diagram illustrating calculation of shear stress.

calculated to be 2 - 4 times higher than P_o. The decrease in calculated $P_a - P_o$ difference with the increase in D indicates a more uniform distribution at higher D of the die. Anvils with the maximum possible working area, and samples of h such that $D/h = 15 - 20$, should be used to measure σ more accurately. This experiment is a continuation of analogous work previously reported by Vereshchagin et al (Explosion Effects No. 2, p. 59) using the Bridgman anvil technique.

Vereshchagin, L. F., E. Ya. Atabayeva, and N. A. Bendeliani. Phase diagram of Bi_2Te_3 at high pressures and temperatures. FTT, no. 8, 1971, 2452-2454.

The phase diagram of semiconducting Bi_2Te_3 in the 40-85 kbar and 20-700°C ranges was plotted on the basis of the experimental isobars and isotherms of electrical resistance R. The R(P) and R(T) functions were measured mostly on single-crystal p - or n-type Bi_2Te_3 wafers in a high-pressure chamber designed at the Academy's Institute of High-Pressure Physics Lithographic stone or AgCl were used as the pressure-transmitting medium. The boundaries of three high-pressure phases are shown on the P-T diagram of Fig. 1.

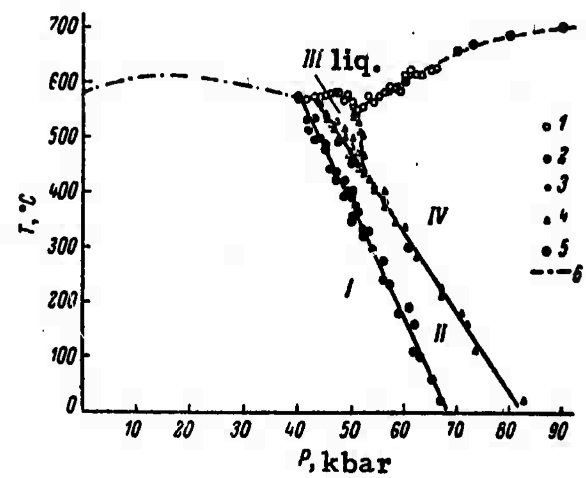

Fig. 1. Phase diagram of Bi_2Te_3.
1 - 4 - electrical resistance method,
5 - DTA method, 6 - data of D.L. Ball (Inorg. chem., 1, 4, 1962)

The phase transition curves are described by the equations

$$P_{I-II} = 68.5 - 0.0493T, \quad P_{II-IV} = 82.8 - 0.0703T, \qquad (1)$$
$$P_{II-III} = 84.0 - 0.0726\,T, \quad P_{III-IV} = 56.1 - 0.0094\,T,$$

and the P-T coordinates of triple points are tabulated (see Table I below).

Equilibrium	P, kbar	T, °C
Liq.+I+II	40.4	570
Liq.+II+III	43.0	566
Liq.+III+IV	50.9	553
II+III+IV	52.0	438

Table 1.

The I - II and II - III transitions are reversible; the II - IV transition is not reversible below 150°C. On cooling, the metallic phase IV yields a metastable phase at 20°C and 25 kbar pressure, intermediate between the phase IV and the original phase. The phase transitions detected are of the second order.

Kalitkin, N. N. and L. V. Kuz'mina. Cold compression curves at high pressures. FTT, no. 8, 1971, 2314-2318.

Pressure P, energy E of elastic compression of an atom, chemical potential, electron density ρ, and intra-atomic potential are calculated at 0° for each element of the Periodic Table. Calculations based on a quantum statistical model (QSM) are shown to be much simpler than the earlier calculatio from the electronic spectra, and also more accurate than calculations based on the Thomas-Fermi model. The pressure P, as the other thermodynamic quantities cited, was expressed as a function of ρ, e.g.

$$P=\left[\frac{1}{5}(3\pi^2)^{2/3}\rho^{5/3}-\frac{1}{4}\left(\frac{3}{\pi}\right)^{1/3}\rho^{4/3}-\frac{\Delta\rho}{36}\right]_{r=R}. \qquad (1)$$

where R is the radius of the Wigner-Seitz cell in the QSM. The tabulated P and E data for 13 elements and for atomic volumes v in the .100 + 0 to .422 + 2 range were then calculated on a BESM-6 computer with a relative error in the -3 to +12% range. Analysis of the calculated numerical data with allowance for ρ (r) $\approx$ Z(v) at ultra-high pressures led to an interpolation formula P(Z, R) which, together with a formula analogous to (3) for a localizable P, were found to be sufficiently accurate. The P(v) curves of the mixtures and compound can be plotted with the help of the cited formulas for P by solving the set of equations

$$P(Z_1, v_1)=P(Z_k, v_k),\ k>1;\ v=\sum_{k=1} v_k. \qquad (2)$$

which describe the equality of P in the cell of various components and the volume additivity, respectively.

Vereshchagin, L. F., A. A. Semerchan, N. N. Kuzin, and Yu. A. Sadkov. Performance of a three-stage high pressure unit with an operational volume of approximately 100 cm^3. DAN SSSR, v. 202, no. 1, 1972, 74-75.

The performance characteristics are discussed of a high pressure, three stage unit designed to produce large blocks of polycrystalline diamond materials and composites based on synthetic polycrystalline diamonds. These materials are suggested for the tooling of the main components of another high pressure unit (with an operational volume of approximately 0.25 cm^3). The use of these materials, with superior physical and mechanical properties, will lead to a substantial increase in the pressure range of the 0.25 cm^3 unit.

Pressures of up to 100 kbar can be realized with the 100 cm^3 unit. Calibration of the unit pressure scale was done using the reference points of Bi_{I-II}, Ba_{II-III}, Bi_{III-IV}, and Sn; and also by the method of electrical resistance using a 10,000 ton press. Concavity of the pressure calibration curve is caused by a relatively small ratio (2:1) of F/F_1, where F is the total force and F_1 is the effective first stage force. (F/F_1 ratio is as much as 5:1 for the 0.25 cm^3 high pressure unit.) The increase of the pressure range and the concavity of the pressure calibration curve are dependent on an increase of the F/F_1 ratio, which is not attainable for the 100 cm^3 unit without a substantial increase in the second and third stage cross-sections. Since larger parts made from the presently used cermet hard alloy (VK-6) would likely suffer a loss in quality due to sintering, the effective development of multistage units is predicated on fabricating at least one of the stages using high strength steel.

The authors note that they have successfully produced large blocks of polycrystalline diamond materials of the ballas and carbonado types using the 100 cm^3 high pressure unit.

The (1) and (2) expressions show that, $\omega - 2\Delta \sim \gamma$, there is a sharp bifurcated peak of the $W_{3\omega}$ harmonic intensity of the electromagnetic field generated by a superconductor specimen subjected to an external field of frequency ω. The ratio of the peak intensity value of $W_{3\omega}$ to its value far from resonance is $\Delta/\gamma \sim (\omega_D/T_c)^2$, where ω_D is the Debye frequency. The $j_{5\omega}$ and higher harmonics also exhibit the cited singularity. Millimeter waves are required to observe the resonance experimentally because actual $\Delta \sim T$.

Polyakov, Ye. V., L. F. Vereshchagin, and Yu. S. Konyayev. Thermal and indicator diagrams for a 16 kbar hydraulic compressor. PTE, no. 6, 1971, 187-188.

From experimentally determined thermal and indicator diagrams for a 16 kbar hydraulic compressor, information is given on the degree of polytropy of compression and expansion processes and properties of the compressor fluid. Also determined are the operational efficiency and characteristics of a plunger seal at high pressures, hydraulic losses, compression chamber fluid level, and the efficiency of the valves. The hydraulic compressor contains a 10 mm diameter plunger moving at a rate of 250 strokes/min and 32 mm stroke spacing. The data were recorded using a resistance thermometer, and tensometric and manganin pressure gages. Calibration, reliability, and other equipment characteristics are discussed. An indicator diagram is presented. A lower than the theoretically predicted operational performance of the hydrocompressor is attributed to leakage through the valve, and the effect of the cylinder's dead space.

Aliyev, F. Yu., I. G. Kerimov, F. R. Godzhayev, Ye. I. Kalinina, and Ye. S. Krupnikov. Superconductivity of CuS semiconductor film. DAN AzSSR, v. 27, no. 9, 1971, 18-19.

Resistivity ρ and relative resistivity $r = \rho / \rho_0$, where ρ_0 is the resistivity at 273°K, of ~600 Å thick CuS films, vacuum deposited on a glass substrate, were measured in the 1.8 - 300°K range. The measurements were made on the theory that the transition to a superconductive state in the films should occur at a higher temperature (up to 10°K) than in bulk crystals. A compensation method was used to measure resistivity. Experimental plots (Fig. 1) show that the pattern of decrease in ρ with a decrease in T is characteristic of superconductors; there is a consequent transition to a superconductive state in CuS films. The transition temperature

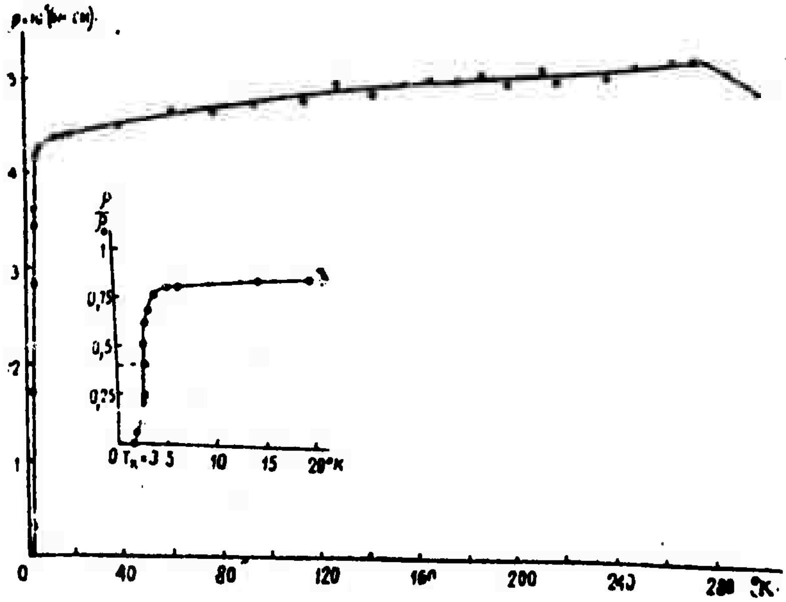

Fig. 1. Resistivity ρ and relative resistivity ρ / ρ_0 versus temperature of CuS films.

$T_k \approx (3.0 \pm 0.3)^oK$ was determined by extrapolation of the r(T) curve. Magnetic measurements are required for a more precise determination of T_k as well as the critical field value. CuS film superconductivity disappears when CuS deviates from stoichiometry during film growth.

Institute for Problems of Mechanics, Academy of Sciences USSR. Seminars. MZhiG, no. 6, 1971, 171-175.

Selected papers presented at four seminars are outlined. The seminars were: (1) a General Seminar from February 25 through June 24, 1971; (2) a Seminar on the Mechanics of a Continuous Medium, from January 8 through July 2, 1971; (3) a Seminar on Mechanics of Solid State Systems and Gyroscopes, from March 15 through May 3, 1971; and (4) a Seminar on Mechanics of Envelopes and Plates from March 10 through June 2, 1971.

Together with seven others, the following two papers were presented to the General Seminar: "Kinetic study of fracture and crack development in polymer materials" by R. L. Lalganik, and "Diffraction of acoustic waves by a moving and a static plate" by Ye. A. Krasil'shchikova. In the latter paper, a weak shock wave incident on a static plate is analyzed in an acoustic approximation. The flow is two-dimensional and vortex-free. An integral equation of the derivative φ_z of the potential $\varphi(x, z, t)$ is solved as in slender wing theory. A solution is devised for successive moments between the intersection of direct and diffracted wave fronts with the plate edges. For a moving plate, an additional operation is necessary to determine the unknown potential behind the plate using the Zhukovskiy relation.

Fourteen papers were presented at the Seminar on the Mechanics of a Continuous Medium. One was titled: "Equations of moments for a uniform turbulence with vortex anisotropy" by Yu. A. Buyevich, and V. N. Nikolayevskiy. General expressions of two-point moments in the case of anisotropy due to the presence of an antisymmetric tensor were analyzed. The correlation tensor of the velocity field is expressed by three independent scalar potentials. Using Navier-Stokes equations, the authors derive separate equations of potentials. Examples are given of correlations identically equal to zero for isotropy and different from zero for the case of vortex anisotropy. The anisotropy corresponds to turbulent flow with an angular velocity kinematically independent of the average velocity field.

Ivlev, B. I., Effects associated with resonant behavior of the energy gap in a superconductor. ZhETF P, v. 15, no. 7, 1972, 441-445.

The problem of determining the nonequilibrium value Δ of the energy gap in a superconducting film in a weak transverse electromagnetic field is treated on the basis of the Eliashberg dynamic equations, in which electron-phonon collisions are accounted for. It is assumed that phase $\Delta = 0$, the film thickness is negligible in relation to the spatial fluctuations of Δ and A, and magnetic impurities are present in a quantity sufficient to justify disregarding electron reflection from the specimen boundary. Solution of the equations to the second order of the field, without accounting for energy relaxation, shows that, at frequency $\omega = 2\Delta$, a small non-stationary additive term to the equilibrium value of the energy gap exhibits a resonant behavior; i. e., normal mode fluctuations of Δ_{ω} are possible in the absence of an external periodic field. The possibility of fluctuation damping due to energy relaxation is demonstrated. At $|\omega - 2\Delta| < \Delta$, the corrected energy gap is expressed by

$$\Delta_{\omega} = 3K\left(\frac{1}{2}\right)\frac{\sqrt{\Delta|\omega - 2\Delta|}}{\omega - 2\Delta + i\gamma} D\left(\frac{e}{c}\right)^{2} A^{2}_{\omega/2} \begin{cases} \dfrac{1}{\pi}, & \omega < 2\Delta \\ \dfrac{1}{\ln(3 + 2\sqrt{2})}, & \omega > 2\Delta \end{cases} \quad (1)$$

where K(1/2) is a complete elliptic integral of the first kind and D is the diffusion coefficient. Calculations reveal that the spatially-homogeneous harmonics of Δ_{ω} are relatively the most durable and the resonance effect is the most pronounced in small specimens and thin films, in the absence of the coordinate-dependence $\Delta_{\omega}(k)$. At $|\omega - \Delta| < \Delta$, the nonlinear current component, proportional to Δ_{ω}, is expressed by the ω-dependence of a type similar to (1)

$$J_{3\omega} = a\frac{\sigma}{c}\Delta_{2\omega}A_{\omega}. \quad (2)$$

where a is expressed through elliptic integrals.

Kopan', V. S., A. V. Lysenko, and V. D. Mikhalko. Effect of surface reinforcement and the medium on properties of aluminum and tin laminated materials. F-KhMM, no. 6, 1971, 15-17.

The purpose of this article is to establish the dependence of microviscosity limits on the specific contribution of the inner surfaces in a multilayer Al-Sn composition (MLC) and to determine possible causes of observed phenomena. The authors establish that the tensile strength of MLC depends on the average thickness of a single layer (the critical thickness is 0.1 μm) and increases with increased inner surface area. The reinforcement is explained by changes in the dislocation structure on the metal interlayer surfaces. Earlier structural studies of the boundaries between the monocrystals of different elements established the existence of an incongruity dislocation lattice acting as an effective barrier for sliding dislocations. The effectiveness of this lattice possibly increases with the increased interlayer area and has a pronounced effect on the microviscosity limits. The existence of a single critical deformation amplitude indicates that the changes of the centers of the dislocation lattice on the interlayer boundary are probable causes of the collapse of the dislocation lattice in MLC layers. Tensile stress has a tendency to increase with a decrease of individual layer thickness. Experimental durability tests of Al-Sn MLC, as a function of time exposure to humidity, show a pronounced decrease of durability with increased exposure. The changes in density and mass of a test sample are explained by interlayer boundary corrosion. Soaking of the sample in distilled water resulted in its total dissolution within 24 hours, comprising non-metallic sediments. The solubility of the sample increased as its layer thickness decreased. The above phenomena are explained by the intensive corrosive processes which take place on the interlayer boundaries.

Terent'yev, V. F., V. N. Stepanov, and L. I. Maslov. Strength of welded joints using type 20 and Kh18N10T steels at 20 to 500°C temperature. F-KhMM, no. 6, 1971, 11-15.

Static and cyclic strength of welded butt joints between type 20 and Kh18N10T steel tubing was investigated in the 20 to 500°C temperature range. The tubing was arc welded using multilayer welding techniques and different type welding rods to create various degrees of structural irregularities between the weld seam and metal. The first two batches were characterized by a decrease of carbon diffusion between the welded tubing in the first, and production of a 30 μ ohm carbon-free band in the second. In the third batch, the use of low carbon welding rods and a multilayer welding technique different from the one used for the first two batches yielded joints free from the structural flaws characteristic of the first two. Analysis of the test results for the tensile strength and structural fatigue due to cyclic loading showed that the location and nature of failure in welded butt joints depends on the temperature. The authors point out that the thermal dependence of tensile strength was influenced by deformation aging of the low-carbon perlite type steel. Deformational reinforcement of the low carbon steel was also a factor in a shift of the location of structural failure in austenitic steel under cyclic loading conditions at blue brittleness temperatures. An increase of structural inhomogeneity between the austenite and perlite steel at 500°C did not lower the fatigue limit of welded steel tubing. Results are tabulated, and graphs show: 1) the dependence of the tensile strength limit on temperature, and 2) structural fatigue as a function of cyclic loading.

Karnozhitskiy, V. P. Experimental investigation of the stability of compressed heated three-layer plates beyond the proportionality limit. IVUZ Aviatsionnaya tekhnika, no. 1, 1972, 128-131.

An experimental investigation was conducted to determine the applicability to the calculation of real plates of a previously proposed empirical formula for determining the critical stresses of asymmetrical plates, nonuniformly heated with respect to thickness beyond the proportionality limit. The formula is analogous to one extensively used in determining the critical stresses of single-layer plates at normal temperatures.

The top and bottom edges of the plate were simply supported. One load-bearing layer was electrically heated to 150-200°C; the other was cooled by carbon dioxide. The experimental rectangular panels consisted of load-bearing layers of equal thickness, made of the same material, glued to a honeycomb filler of AMGN material 0.05 mm thick, made of hexagonal cells, with 4.18 mm sides. Three aluminum alloys, a titanium alloy, and steel were used as materials for the load-bearing layers. The panel length (measured along the compressing force) of the 31 panels tested varied from 290 to 300 mm, and the width from 216 to 300 mm. The mean temperature of the heated load-bearing layer in various panels was alternated from 293 to 455° K, that of the cooled side from 273 to 363° K.

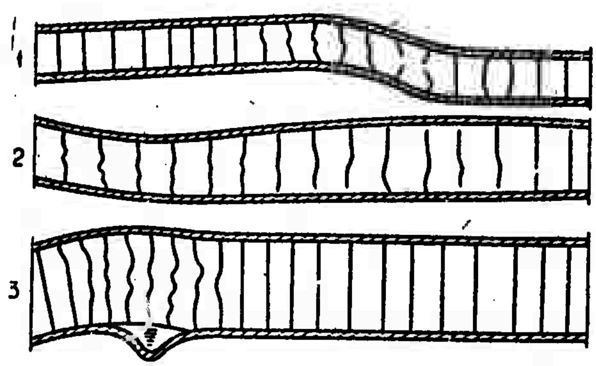

Figure 1.

Fig. 1. Failure modes in honeycomb structures

Three types of panel stability loss are observed: a) Skew-symmetric buckling, when the compression stresses in the load-bearing layers attain the theoretical critical value; this takes place if the stresses at the junction point of the load-bearing layer with the filler are insufficient for detachment of this layer from the filler or for stability loss of the honeycomb walls (Figure 1, plate 1). b) Buckling with stability loss (crumpling) of the filler honeycomb, when the stresses at the junction point of the load-bearing layer with the filler attain a value which is sufficient for stability loss of the honeycomb filler (Figure 1, plate 2); the forces compressing the panel have not reached their theoretical critical value. c) Buckling with detachment of the load-carrying layer, when the stresses at the junction point of the load-bearing layer with the filler attain a value which is sufficient for detachment of the load-carrying layer from the filler (Figure1, plate 3), the forces compressing the panel have also not reached their theoretical critical value.

The conclusion is drawn that the influence of initial unevenness upon the stability of three-layer constructions with a honeycomb filler can be significant; and a theory is required for verifying the strength and stability of the honeycomb filler of compressed heated three- layer constructions with any initial unevenness, both before and beyond the proportionality limit.

When plates of the described type containing load-bearing layers of aluminum alloys no thicker than 1 mm and an initial unevenness no greater than 0.3 mm, are heated nonuniformly with respect to thickness, the critical compression stresses can be determined in a first approximation on the basis of the proposed empirical formula, with 0.85 as the experimental factor. Honeycomb cells of an aluminum alloy, or of a harder material, must have a thickness of not less than 0.05 mm and hexagonal sides not longer than 4.18 mm. Thicker load-carrying layers or greater initial unevenness will yield exaggerated results.

An additional experiment is necessary to determine the possibility of application of the empirical formula for the calculation of three-layer panels with load-bearing layers of titanium alloys and steel. When designing three-layer structures with load-bearing layers of titanium and steel, it is necessary to increase the stability of the honeycomb walls by increasing their thickness or by decreasing the dimensions of the hexagon.

Geogdzhayev, V. O., V. I. Kondayrov, E. B. Fel'dman. Accounting for anisotropy of material in the planar plastic deformation state. PM, no. 12, 1971, 107-111.

Results are presented of theoretical studies on the effects of anisotropy in metals in a state of plastic plane deformation on the tension distribution and limiting loads for three specific cases. General expressions for a plane plastic deformed state of orthotropic materials and Mises-Hill viscosity conditions are used as a starting point. For a thick orthotropic bar with a deep cut and an applied tensile force, the authors give expressions for functions (x and y) which satisfy Mises-Hill viscosity conditions, as well as expressions for the plastic region angle and the maximal tensile force P. A graph of P/2k' (h-R), as a function of γ, for various k/k' values is given. (P = maximal tensile force, k and k' = constants of material, given in terms of viscosity limits, h = $\frac{1}{2}$ bar width, R = radius of the cut, γ = the characteristic angle of plastic region.) For a sharp wedge under a uniform load, critical regions and characteristic parameters are schematically represented on a diagram. An equation for the maximal load P is obtained using continuity conditions and P/k is plotted as a function of k/k' and γ. The functions y and x are given for two critical regions. The third case analyzed as the stamping process of a wedge-shaped die with rough edges into a similarly shaped cut in a rigidly-plastic orthotropic wedge. With certain assumptions on the friction force and stamping speed, an expression for the normal pressure along the contact line is obtained. The vertical and horizontal components of the resultant force along the contact line can be obtained from this expression, as well as the moment acting on the die. Relative force as a function of k/k' is plotted for various values of the wedge angle. The anisotropy considerably affects the state of stress and the maximum loads, and a nonlinear relation exists between k/k' (anisotropy constant), characteristic parameters and maximum loads.

Golyanov, V. M., A. P. Demidov, M. N. Mikheyeva, and A. A. Teplov. <u>The superconducting transition temperature and structure of film specimens of carbon-alloyed molybdenum.</u> ZhETF P, v. 15, no. 7, 1972, 365-367.

A superconductivity experiment is described in which the temperature-dependence of electrical resistance was measured, and electron micrographs and diffraction patterns were studied, in film specimens of carbon-alloyed Mo. The specimens were prepared by cathodic sputtering of alternating Mo and C monoatomic layers or simultaneous sputtering of Mo and C and condensation on a glass substrate at liquid nitrogen temperature. The rate of sputtering for the first method was 7 Å/min for Mo and 2 Å/min for C. Critical temperature T_c was determined by resistance $R = Rn/2$, where Rn is the resistance measured after transition into the normal state. The pattern of T_c dependence on C concentration was identical for specimens prepared by either of the two techniques. A typical pattern for a ~60 Å thick film shows a plateau of maximum $T_c = 6.9 \pm 0.1^{\circ}K$ (Fig. 1).

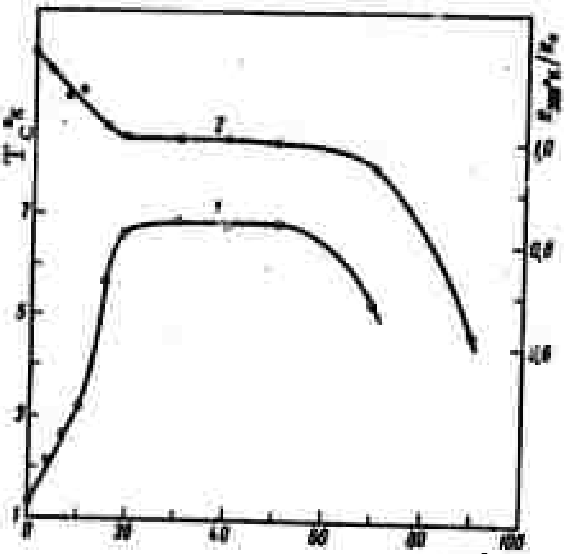

Fig. 1. Critical temperature (curve 1) and the $R_{300^{\circ}K}/R_n$ ratio (curve 2) versus C concentration for Mo-C specimens.

At 16 at%, T_c is practically independent of film thickness within the 50-120 Å range, but drops abruptly at a thickness below 30 Å. A 60 Å thick film with 90 at% C did not exhibit a superconducting transition above 1.5°K. Diffusion of diffraction peaks and an increase of lattice parameters were observed in the films with increasing C content. At a C content above ~30 at%, the grain size decreased from ~70 Å to ~10 Å; Mo-C alloys to ~20 at % C had a grain size equivalent to pure Mo. Deformation of the Mo crystal lattice is the most probable cause of a T_c increase in the presence of an admixture. No correlation was found between T_c variations and grain size in the range of C concentrations in which T_c increased.

Skupskaya, E. V. <u>Features of the destruction process of silicate glass in air and vacuum.</u> F-KhMM, no. 6, 1971, 92-94.

Results of a number of theoretical and experimental studies on the processes of shattering in defective and perfect silicate glass are analyzed. Shattering activation energy and a structural coefficient are determined both from plotted experimental data and equations. Agreement is found for certain temperature ranges. The coefficient of stress concentration is qualitatively determined for silicate glass from tabulated values of structural coefficients. The coefficient is greater for the defective than for the perfect glass; it also depends on the test environmental conditions, being greater for glass tested in vacuum than under normal atmospheric conditions. Shattering activation energy is also lower for silicate glass tested under normal atmospheric conditions over that tested in a vacuum, due to atmospheric moisture. The activation energy is considerably lower for glass with surface cracks, where a high stress concentration level exists, than for smooth etched glass.

Naumenko, I. G., and V. I. Petinov. Increase of T_c in finely-dispersed tin. ZhETF P, v. 15, no. 8, 1972, 464-467.

The effects of particle size and oxidation depth on critical temperature T_c were studied in granulated tin samples, prepared by compacting finely dispersed tin powder under 8 kbar pressure. The disc-shaped, 8 mm diam., 1 mm thick, and 5 g/cm^3 density, samples consisted of β-tin spherical particles coated with oxide layers. Particle size was determined by electron microscopy, and oxidation depth by the amount of absorbed oxygen and the Mossbauer effect. The size effect of particles with two monolayer coatings on T_c, determined by two independent methods, is shown in Fig. 1., where r_{av} is the average particle radius and T_{co} is the critical temperature of the solid superconductor.

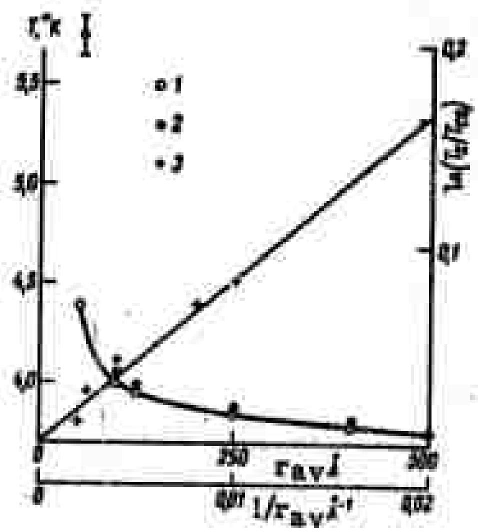

Figure 1. T_c versus particle radius and $\ln (T_c/T_{co})$ versus $1/r_{av}$: 1- T_c determined from the experimental magnetic susceptibility $\chi(T)$, 2- T_c determined from the experimental resistance R(T), when R = 0.5 Rn, 3 - $\ln(T_c/T_{co})$ versus $1/r_{av}$.

For particle r_{av} = 100 Å, the plots of R/Rn transition and χ versus T (Fig. 2) show that the presence of two oxide monolayers causes a significant increase in T_c.

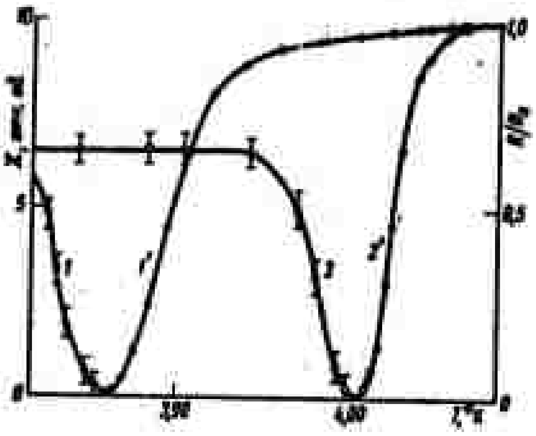

Fig. 2. Plots of R/Rn and χ versus T in the region of superconducting transition in samples with different oxidation depths: 1, 1'-<5%, 2, 2'-~20%, 1',2'-R/Rn, 1, 2-χ(T)

The experimental $\ln(T_c/T_{co})$ versus $1/r_{av}$ plots (Fig. 1) are in qualitative agreement with theoretical data based on the exciton mechanism of superconductivity of dielectric-coated metal particles. The singular conclusion, however, that the experimentally observed increase in T_c is connected with the exciton mechanism cannot be supported because of the uncertain existence of the exciton bands below the Fermi surface in tin oxides.

Postnikov, V. V., and I. V. Zolotukhin. Superconductivity of dual-layer Bi-Pb films. FiKhOM, no. 2, 1972, 155-157.

The superconducting transition temperature T_k was determined experimentally in Bi-Pb "sandwich" films, 400, 600, and 800 Å thick, vacuum-deposited on a single crystal silicon oxide substrate. The Bi film was first deposited on the substrate, then a Pb film of equal thickness was condensed over it. To minimize interdiffusion between the films, deposition of both films was carried out at 4.2°K. Typical experimental data are plotted in Fig. 1. show an increase in T_k after Pb deposition from 6.25 to 8.28°K.

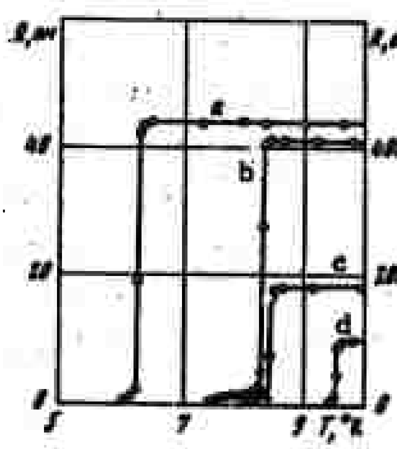

Fig. 1. Superconducting transition plots of a Bi (400 Å) - Pb (400 Å) film deposited at 4.2°K on a polished silicon oxide single-crystal substrate. R values are on the right of the figure for a, d curves and on the left for b, c curves. a- freshly deposited Bi film; b- Bi-Pb film after Pb deposition; c- Bi-Pb film annealed to 200°K; d- Bi-Pb film held at 300°K for 10 hr.

The latter T_k of the Bi-Pb sandwich is relatively high in comparison to a freshly-deposited Pb film alone. The increase in T_k is explained by the effect of proximity of the Bi film to the Bi-Pb film formed by diffusion across

the Bi-Pb interface and having a high T_k. The significant increase in T_k of the sandwich film after a 10-hr aging at room temperature (Fig. 1d) is due to a complete "intermixing" of the layers, i.e. formation of Bi-Pb alloy throughout the film thickness. Prolonged aging at room temperature did not affect T_k, since formation of the film was completed in 10 hr. The 400 and 600 Å thick films gave similar results, which are tabulated.

Lazarev, B. G., L. S. Lazareva, and V. A. Poltavets. <u>Producing a uniform stationary magnetic field in superconductor solenoids using a shield made from a superconductor with extended parameters.</u> DAN SSSR, v. 203, no. 4, 1972, 810-812.

Experimental data are summarized on the use of a Nb_3Sn superconducting shield as an insert in a short superconducting solenoid to create an extended, highly uniform field. The experimental solenoid, made of Nb-60at%Ti wire, was 70 mm long with a 20 mm ID and an 80 mm OD. The measured magnetic field intensity $\bar{H}$ was in the 5,000-55,000 Oe range. The shield was made of a 40 mm wide capacitor paper strip with spaced Nb_3Sn bands glued across the strip. The paper strip was wound on a 11 mm diam. plexiglass bobbin in 27, 50, or 72 layers. The Nb_3Sn band was 10 mm wide and ~30μ thick with a critical current value ~250 a in a 6×10^4 oe field. The cylinder-shaped shield, with a slit along its generatrix, was inserted into the solenoid symmetrically in relation to its center (Fig. 1).

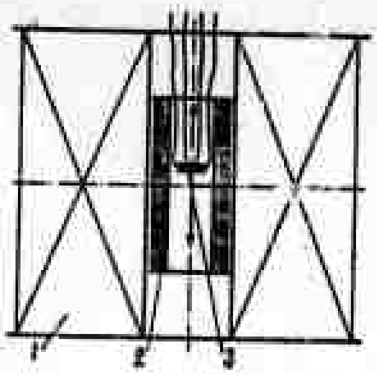

Fig. 1. Arrangement for field equalizing along the solenoid axis: 1- superconducting solenoid; 2- shield-insert; 3- magnetometer.

The measured H data near the center of the solenoid along its axis (Fig. 2) show clearly the field-equalizing effect of the shield.

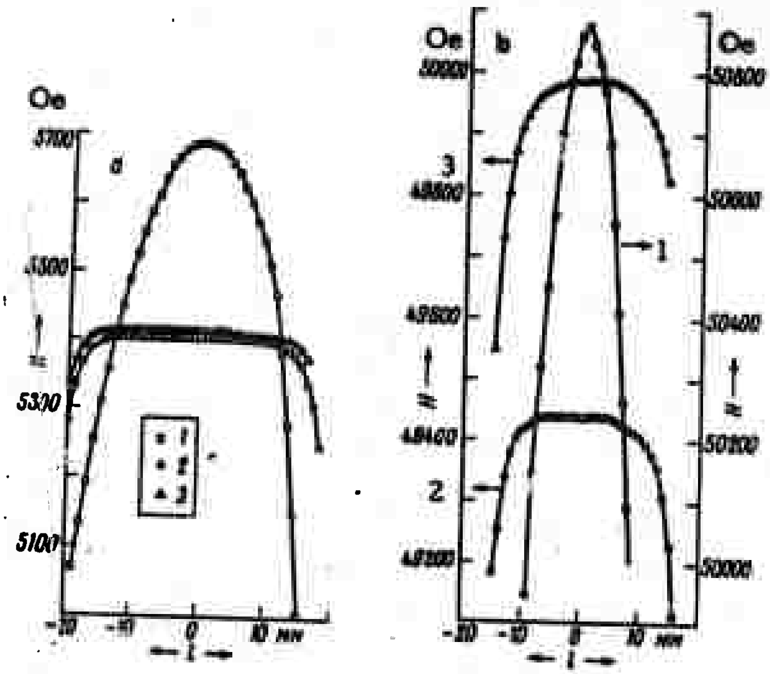

Fig. 2. Equalizing effect of the shield-insert on H~5,700 (a) and 50,000 oe (b) fields: 1- without the shield; 2- with a 72-layer shield; 3- with a 27-layer shield.

Analogous data were obtained in the ~14,000 and 25,.000 oe fields. The region of uniform field shrinks and the shield efficiency decreases with an increase in H, because of a decrease in the critical current value of Nb_3Sn. Fig. 2 also shows that H of the solenoid magnetic field is decreased somewhat by the shield. The field-equalizing effect of the shield was maintained during measurements with decreasing field H, but a hysteresis loop appeared in the region of uniform H. An accuracy of about 1 oe was attained in the field measurements.

Vystavkin, A. N., V. N. Gubankov, L. S. Kuz'min, K. K. Likharev, and V. V. Migulin. Characteristics of parametric regeneration in superconducting point contacts. RiE, no. 4, 1972, 896-899.

The possibility of parametric amplification and conversion of signals by a superconducting point-contact Josephson junction is discussed for an open-circuit system with self-pumping at SHF frequencies. Analysis of the parametric interactions was based on the mathematical model developed by the authors [RiE, no. 11, 1970, 4204] for a short-circuited point-contact system. Resistance R_1 of the point-contact junction in an open-circuit single-frequency system at a ω_1 input signal frequency was formulated as

$$R_1 = Z_{11} = R\left[1+\frac{\sqrt{1+\Omega^2}-\Omega}{2}\left(\frac{1}{\Omega-\Omega_1}+\frac{1}{\Omega+\Omega_1}\right)\right]. \qquad (1)$$

where R is the junction resistance in the normal state, Ω is the normalized Josephson frequency $\Omega_1 = \omega_1/\omega_0$, and ω_0 if the characteristic frequency of the junction. Eq. (1) and the corresponding plots (Fig. 1) show that $R_1<0$ in the region of $\Omega_1 \geq \Omega$, which shrinks when $\omega^{(0)}$ is increased. The formula of $|R_1|$ max. indicates the possibility of $|R_1| \geq R$ for a weak signal (intensity of parametric oscillations $\tilde{I} \leq I_0$). The coincidence of the maximum

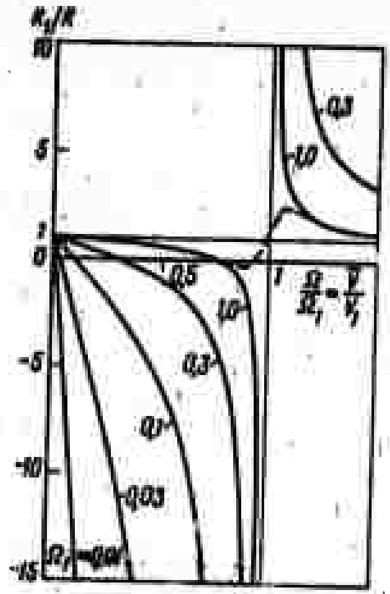

Fig. 1. Junction resistance at ω_1 frequency versus $\omega^{(0)}$ pump frequency (V = bias voltage). The dashed line indicates as approximate distortion pattern due to increased generation bandwidth.

normalized voltage (V_1) max at the ω_1 frequency with V_1 in the synchronized region implies a smooth transition from the $R_1 < 0$ to the synchronized region. The resistance matrix developed for a junction interacting with oscillations at two frequencies: $\omega_1 = \omega_0 \Omega_1$ and $\omega_2 = \omega_0(\Omega_1 - \Omega)$ suggests the possibility of a regenerative conversion to a lower frequency even in the absence of a resonant cavity at ω_2, if $\omega_1 - \omega_2 = \omega^{(0)}$ and $R_1 < 0$. In contrast, regenerative parametric amplification is impossible at $R_1 > 0$ ($\Omega_1 < \Omega$) and $\omega_1 + \omega_2 = \omega^{(0)}$. For interaction with a single frequency (Eq. (1) and Fig. 1), the effect of negative resistance is dissipated at distances near ω_1 of the order of the generation bandwidth.

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6. Miscellaneous Interest

A. Abstracts

Gorlin, G. B., L. G. Paritskiy, S. M. Ryvkin, and A. A. Bagdanavichus. Potentialities of the "semiconductor-dielectric" electrophotographic system in long wave semiconductor photography. FTP, no. 2, 1972, 427-428.

Charge transfer between a semiconductor and a dielectric in a liquid medium at a low temperature was examined in connection with the possibility of extending electrophotography into the long wave region using a semiconductor-dielectric system. Experiments were carried out with a 1,000 μ thick, Zn-doped GaAs layer, of 10^8 ohm x cm resistivity, and a 10 μ polyethylene dielectric film with a conductive coating. In the first experiment, both layers were clamped between conducting electrodes and completely immersed in liquid nitrogen. No charge transfer was detected during simultaneous illumination of the system with a 3×10^{-2} w/cm^2 optical beam and application of 80 msec current pulses at potentials up to 8 kV. The electrode system at liquid nitrogen temperature was only partly immersed in liquid nitrogen in subsequent experiments, so that the semiconductor-dielectric contact was maintained above the nitrogen surface. After 5-10 sec in this position, the electrodes were illuminated and an 80 msec current pulse at $\sim$3 kV potential was simultaneously applied. Charge transfer was detected across the semiconductor-dielectric gap filled with nitrogen gas. Clear electrophotographic images were thus obtained on the dielectric in the spots corresponding to the illuminated regions of the semiconductor. The experimental results support the feasibility of a long wave photographic process using a semiconductor-dielectric electrophotographic system.

Groshev, I. N., L. B. Fuks, Yu. P. Yareshko and P. I. Yashchishin. Limiting energetic effectiveness of an shf-scanning r-f image converters. RiE, no. 4, 1972, 894-896.

This article considers efficiency limits on shf-scanning converters of r-f. Two working principles of the converters are: a) image dispersion, and b) collection of shf energy of image elements in a common waveguide channel, from which the energy is transferred to the input of a typical single channel shf-receiver. Energetic efficiency of the system is the decisive factor for determining the possible field of its application. Simplified block diagrams of the scanning converter and shf energy collector

are shown in figures 1 and 2. The operational characteristics of an ideal

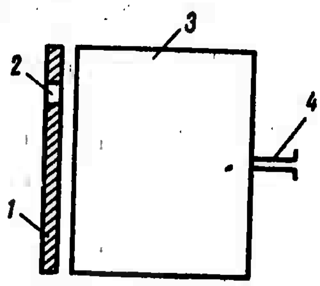

Fig. 1. Scanning converter
1- Filter plate
2- Aperture
3- Energy collector
4- Waveguide output

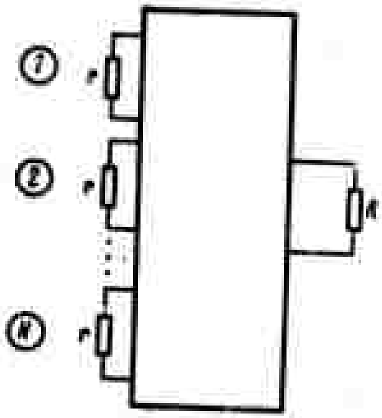

Fig. 2. shf energy collector

converter are briefly discussed. The limiting value of the coefficient of shf power transmission should not exceed 1/N, where N is the number of dispersed elements. For practical applications, $N \approx 10^2 - 10^3$ and $K \leq 1/N = -(20 \sim 30)$ db. The values are in good agreement with those in the literature. Scanning converters of the type discussed, irrespective of their technological contribution, are in principle characterized by low energy efficiency, which should be considered when evaluating their application potential.

Alekhin, V. P., S. S. Dryunin, A. G. Zhdanovich, V. I. Kryuk, R. I. Mints, and I. I. Mil'man. Exoelectronic emission from tension-deformed silicon. FiKhOM, no. 2, 1972, 132-133.

Experiments were carried out with polished n-type silicon samples to verify a presumed correlation between exoelectronic emission and the defects created by surface deformation. This presumption was based on earlier finding by two of the authors on the surface treatment dependence of the exoelectronic emission parameters from Si and Ge. The Si samples were tension-stressed at 900°C in vacuum at a 1.5×10^{-4} sec^{-1} rate in the ⟨111⟩ direction.

The plastic deformation ϵ was in the 0.1 - 0.6% range. The tension-deformed samples were heated in vacuum at a 0.28° /sec rate and simultaneously illuminated with a focused optical beam of 280μ wavelength. The photostimulated exoelectronic emission was then

recorded. Typical exoelectronic emission curves show only a weak strain percent-dependence of the emission peak position versus temperature. However, the emission peak intensity increased with an increase in ϵ (Fig. 1).

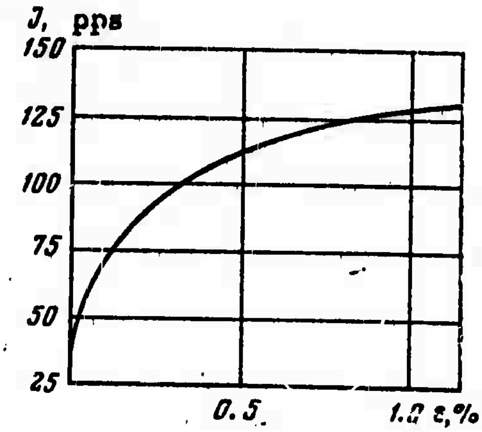

Fig. 1. Intensity of exo-emission from Si vs. percent strain ϵ

Findings indicate that the elementary exo-emission phenomena on the surface of tension-deformed samples are similar. The analogy between the plot in Fig. 1 and the earlier observed strain percent-dependence of dislocation density suggests that the electron emission from semiconductors occurs preferentially at the points of dislocation emergence on the surface. The calculated values of activation energy of exo-emission at different strain percentages are explained in terms of diffusion migration of point defects through the surface layers.

Trubnikov, B. A. Nature of ball lightning. DAN SSSR, v. 203, no. 6, 1972, 1296-1298.

In an attempt to clarify the origin of the alleged 10 - 20 cm radio waves in lightning discharges, the author introduces modifications to the Dawson-Jones model of ball lightning. (Pure and Appl. Geophys., v. 75, 247, 1969). The principal modification assumes that the cavity which is hypothetically formed in the channel of ordinary straight lightning, is filled with radiation of characteristic wavelength in the millimeter or sub-millimeter range. This assumption

is based on the so-called "ionosphere effect" on radio wave formation and propagation in the lightning channel. The plasma frequency, ω_o in the sheath around the channel increases by multiple discharges of lightning to a value corresponding to submillimeter wavelengths in vacuum. The waves of a frequency $\omega < \omega_o$ from the channel cannot penetrate the plasma and are therefore reflected. Powerful radio waves of a frequency $\omega < \omega_o$ consequently accumulate progressively in the space surrounded by the plasma sheath and propagate along the lightning channel. The proposed model of ball lightning formation (Fig. 1) comprises three successive stages. In the first stage,

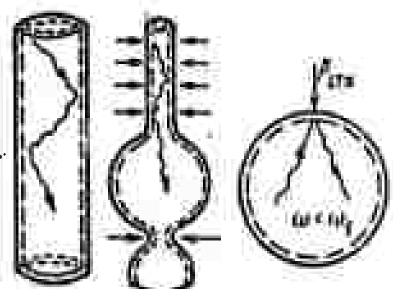

Fig. 1. Ball lightning formation model

(Fig. 1a), electron density in a cylindrical discharge (Z-pinch) increases, i. e., a "light lock" is formed, in a channel constriction. In the next stage (Fig. 1b), a pear-shaped bulge is formed above the constriction by radiation emitted from the compressed upper channel. In rare cases, the bulge may expand by radiation pressure from above to a ball (Fig. 1c), which is sustained by intense oscillations in the cavity, even after the main discharge ceases. In contrast to the Dawson-Jones hypothesis, the horizontal propagation of ball lightning is here explained by its preferential repulsion from the ball's hot trail of free electrons. The same effect may counterbalance the buoyancy force. The radiation pressure in the sphere must exceed atmospheric pressure; hence the total stored energy could be higher than in the Dawson-Jones model. This hypothesis is supported by the hypothetical structure of the plasma sheath (Fig. 2).

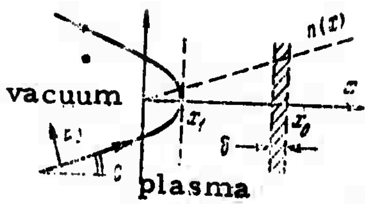

Fig. 2. Hypothetical model of plasma sheath around a ball lightning cavity

The wave field at the point x_o, with an estimated amplitude $E_x > E_o$ of the incident wave and concentrated in a very narrow slit δ is presumably capable of creating a thin shield which protects the cavity from the external neutral gas flux. Ionization of neutral molecules in the slit and their ejection by electrodynamic forces may increase external pressure, and the energy content of the cavity.

Pryadkin, K. K., R. V. Mitin, and N. N. Klimov. Electrodeless discharge in xenon at pressures to 40 atm. IN: Fizika plazmy i problemy upravlyayemogo termoyadernogo sinteza. Kiyev. Izd-vo Naukova dumka, no. 1, 1971, 226-230.

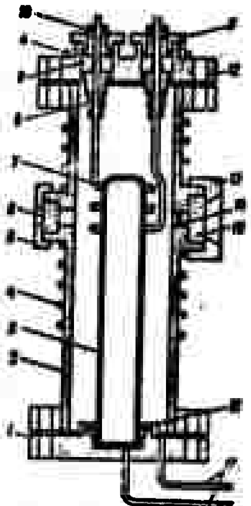

Fig. 1. Sketch of discharge chamber with external support. 1 - lower flange; 2 - stable metallic chamber; 3 - quartz tube; 4 - cooling coil; 5, 11, 13 - nut; 6, 15 - observation ports; 7 - HF generator; 8 - teflon seal; 9 - quartz seal; 10 - teflon insulator; 12 - upper flange; 14 - projection camera; 16 - tightening ring; 17 - connection pipe.

Electrodeless high-frequency discharges in xenon at pressures to 40 atm were studied and the possibility of generating such discharges at still higher pressures was demonstrated. A fractional radiant energy

loss in the overall discharge energy balance was determined as a function of discharge power and chamber pressure within the interval of 0.1 - to 40 atm. The maximum radiated power achieved at pressures of 5 to 40 atm was about 3.5 kw and the maximum light flux was about $1.5 \cdot 10^5$ l. Two discharge chamber structures were used: a thick-walled quartz chamber cooled by air or water, and a water-cooled chamber with an external support, illustrated in Fig. 1. Experimental procedures are outlined and results are plotted.

B. Recent Selections

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7. SOURCE ABBREVIATIONS

APP	-	Acta physica polonica
DAN ArmSSR	-	Akademiya nauk Armyanskoy SSR. Doklady
DAN AzSSR	-	Akademiya nauk Azerbaydzhanskoy SSR. Doklady
DAN BSSR	-	Akademiya nauk Belorusskoy SSR. Doklady
DAN SSSR	-	Akademiya nauk SSSR. Doklady
DAN TadSSR	-	Akademiya nauk Tadzhikskoy SSR. Doklady
DAN UkrSSR	-	Akademiya nauk Ukrainskoy SSR. Dopovidi
DBAN	-	Bulgarska akademiya na naukite. Doklady
EOM	-	Elektronnaya obrabotka materialov
FAiO	-	Akademiya nauk SSSR. Izvestiya. Fizika atmosfery i okeana
FGiV	-	Fizika goreniya i vzryva
FiKhOM	-	Fizika i khimiya obrabotki materialov
F-KhMM	-	Fiziko-khimicheskaya mekhanika materialov
FMM	-	Fizika metallov i metallovedeniye
FTP	-	Fizika i tekhnika poluprovodnikov
FTT	-	Fizika tverdogo tela
GiA	-	Geomagnetizm i aeronomiya
IAN Arm	-	Akademiya nauk Armyanskoy SSR. Izvestiya
IAN Az	-	Akademiya nauk Azerbaydzhanskoy SSR. Izvestiya
IAN B	-	Akademiya nauk Belorusskoy SSR. Izvestiya. Seriya fiziko-matematicheskikh nauk
IAN Energ	-	Akademiya nauk SSSR. Izvestiya. Energetika i transport

IAN Fiz	-	Akademiya nauk SSSR. Izvestiya. Fizika
IAN Fizika zemli	-	Akademiya nauk SSSR. Izvestiya. Fizika zemli
IAN Kh	-	Akademiya nauk SSSR. Izvestiya. Seriya khimicheskaya
IAN Lat	-	Akademiya nauk Latviyskoy SSR. Izvestiya
IAN Metally	-	Akademiya nauk SSSR. Izvestiya. Metally
IAN Mold	-	Akademiya nauk Moldavskoy SSR. Izvestiya. Seriya fiziko-tekhnicheskikh i matematicheskikh nauk
IAN SO SSSR	-	Akademiya nauk SSSR. Sibirskoye otdeleniye. Izvestiya
IAN Tadzhikskoy SSR	-	Akademiya nauk Tadzhikskoy SSR. Izvestiya. Otdeleniye fiziko-matematicheskikh i geologo-khimicheskikh nauk
IAN UzbSSR	-	Akademiya nauk Uzbekskoy SSR. Izvestiya. Seriya fiziko-matematicheskikh nauk
I-FZh	-	Inzhenerno-fizicheskiy zhurnal
ILEI	-	Leningradskiy elektrotekhnicheskiy institut. Izvestiya
IT	-	Izmeritel-naya tekhnika
IVUZ Aviatsionnaya tekhnika	-	Izvestiya vysshikh uchebnykh zavedeniy. Aviatsionnaya tekhnika
IVUZ Chernaya metallurgiya	-	Izvestiya vysshikh uchebnykh zavedeniy. Chernaya metallurgiya
IVUZ Elektromekhanika	-	Izvestiya vysshikh uchebnykh zavedeniy. Elektromekhanika
IVUZ Energ	-	Izvestiya vysshikh uchebnykh zavedeniy. Energetika
IVUZ Fiz	-	Izvestiya vysshikh uchebnykh zavedeniy. Fizika
IVUZ Mashinostroyeniye	-	Izvestiya vysshikh uchebnykh zavedeniy. Mashinostroyeniye

IVUZ Priboro	-	Izvestiya vysshikh uchebnykh zavedeniy. Priborostroyeniye
IVUZ Radioelektr	-	Izvestiya vysshikh uchebnykh zavedeniy. Radioelektronika
IVUZ Radiofiz	-	Izvestiya vysshikh uchebnykh zavedeniy. Radiofizika
IVUZ Tsvetnaya metallurgiya	-	Izvestiya vysshikh uchebnykh zavedeniy. Tsvetnaya metallurgiya
KiK	-	Kinetika i kataliz
KL	-	Knizhnaya letopis'
Kristall	-	Kristallografiya
KSpF	-	Kratkiye soobshcheniya po fizike
LZhS	-	Letopis' zhurnal'nykh statey
MiTOM	-	Metallovedeniye i termicheskaya obrabotka materialov
MP	-	Mekhanika polimerov
MTT	-	Akademiya nauk SSSR. Izvestiya. Mekhanika tverdogo tela
MZhiG	-	Akademiya nauk SSSR. Izvestiya. Mekhanika zhidkosti i gaza
NK	-	Novyye knigi
NM	-	Akademiya nauk SSSR. Izvestiya. Neorganicheskiye materialy
OiS	-	Optika i spektroskopiya
OMP	-	Optiko-mekhanicheskaya promyshlennost'
Otkr izobr	-	Otkrytiya, izobreteniya, promyshlennyye obraztsy, tovarnyye znaki
Phys abs	-	Physics abstracts
PM	-	Prikladnaya mekhanika

PMM	-	Prikladnaya matematika i mekhanika
PSS	-	Physica status solidi
PTE	-	Pribory i tekhnika eksperimenta
RiE	-	Radiotekhnika i elektronika
RZhElektr	-	Referativnyy zhurnal. Elektronika i yeye primeneniye
RZhF	-	Referativnyy zhurnal. Fizika
RZhKh	-	Referativnyy zhurnal. Khimiya
RZhMekh	-	Referativnyy zhurnal. Mekhanika
RZhMetrolog	-	Referativnyy zhurnal. Metrologiya i izmeritel'naya tekhnika
RZhRadiot	-	Referativnyy zhurnal. Radiotekhnika
TiEKh	-	Teoreticheskaya i eksperimental'naya khimiya
TKiT	-	Tekhnika kino i televideniya
TMF	-	Teoreticheskaya i matematicheskaya fizika
TVT	-	Teplofizika vysokikh temperatur
UFN	-	Uspekhi fizicheskikh nauk
UFZh	-	Ukrainskiy fizicheskiy zhurnal
VAN	-	Akademiya nauk SSSR. Vestnik
VAN BSSR	-	Akademiya nauk Belorusskoy SSR. Vestnik
VAN KazSSR	-	Akademiya nauk Kazakhskoy SSR. Vestnik
VLU	-	Leningradskiy universitet. Vestnik. Fizika, khimiya
VMU	-	Moskovskiy universitet. Vestnik. Seriya fizika, astronomiya
ZhETF	-	Zhurnal eksperimental'noy i teoreticheskoy fiziki
ZhETF P	-	Pis'ma v Zhurnal eksperimental'noy i teoreticheskoy fiziki

ZhFKh	-	Zhurnal fizicheskoy khimii
ZhNKh	-	Zhurnal neorganicheskoy khimii
ZhNiPFiK	-	Zhurnal nauchnoy i prikladnoy fotografii i kinematografii
ZhPK	-	Zhurnal prikladnoy khimii
ZhPMTF	-	Zhurnal prikladnoy mekhaniki i teoreticheskoy fiziki
ZhPS	-	Zhurnal prikladnoy spektroskopii
ZhTF	-	Zhurnal tekhnicheskoy fiziki
ZhVMMF	-	Zhurnal vychislitel'noy matematiki i matematicheskoy fiziki

8. AUTHOR INDEX